VOLUME XXXIX NUMBER 3

BOTANICAL GAZETTE

MARCH, 1905

GAMETOPHYTES AND EMBRYO OF TORREYA TAXIFOLIA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LXIX.

JOHN M. COULTER and W. J. G. LAND.

(WITH PLATES A, I, II, III)

Torreya taxifolia Arnott[1] occurs in a narrow belt along the eastern side of the Apalachicola River, extending from the southern boundary of Georgia for about thirty miles southward (1). In April 1904 this region was visited by H. C. COWLES of this laboratory, among whose notes the following are of interest in this connection:

My visit was to the northernmost colony, west of Chattahoochee village, and close to the Georgia line. The distribution lines on CHAPMAN's map (1) would lead one to suppose that the tree is xerophytic and frequents the steep and dry eastern bluffs. I was much surprised to find that it was confined (in the Chattahoochee station at least) to the extremely mesophytic slopes of ravines, growing exclusively in the shade of trees, and in places that are continually moist, preferably on slopes facing north. The northern and southern known limits of the tree are only about thirty miles apart, and the east-west range is much less. Furthermore, on account of the great economic value of the wood, and the familiarity of the tree to all the inhabitants of the region, the likelihood of finding other areas is very slight.

It is associated with a remarkable and somewhat extensive group of northern mesophytic plants, and the conclusion is irresistible that Torreya is a northern plant of the most pronounced mesophytic tendencies, and to be associated with

[1] Unfortunately, Torreya was used at least three times as a generic name, in as many families, before 1838, the date of the publication of *Torreya* Arnott. Hence ARNOTT'S genus has been replaced by *Tumion* Raf., and our species becomes *Tumion taxifolia* Greene. In the present paper, however, the more familiar name is used for convenience.

such forms as the beech-maple-hemlock forms of our northern woods, our most mesophytic type of association. Probably it never becomes a large tree, although farmers always cut the trees as soon as they become at all usable. Rarely were any found over 30^{cm} in diameter or more than 9 to 12^{m} high. It has remarkable capacity for vegetative reproduction, almost equaling the redwood in this respect. Many suckers issue from cut stumps, and even from fallen trunks; even rotten stumps show vigorous suckers, and it seems to be as tenacious of life as the poplar. Staminate trees appear to be the more numerous; however, when in blossom they are far more conspicuous than are the pistillate trees, and the conclusion as to proportion may not hold.

COWLES secured collections of staminate and ovulate material April 4 and 5, and arranged for subsequent collections to be sent to the laboratory. These collections were made at intervals of approximately two weeks up to October 21. The strobilus-bearing twigs were packed in damp cotton in tightly closed tin buckets and reached the laboratory in good condition in about five days. The length of the intervals between collections and between collecting and killing has prevented so close a series as is desirable at certain stages, but the gymnosperm periods are so long that a fair outline of morphological events was secured.

SPERMATOGENESIS.

STROBILI.—The staminate strobili occur in the axils of leaves of young shoots. Their appearance in October, on a shoot of the same season, is shown in *fig. 1*. At this time they are small and ovoid, solitary in the axil of each leaf, and by a curving of the short peduncles are displayed along the under surface of the shoot. The strobilus consists of a series of closely overlapping sterile bracts, in four vertical rows, completely enveloping the tip of the axis bearing numerous stamens. It is thus distinctly sterile below and fertile above, the sporophylls continuing the spiral succession developed by the bracts (*figs. 6* and *7*).

The young strobili were first observed in July, and at that time no primordia of sporophylls were evident; but in August these were beginning to appear. *Fig. 7* is from a longitudinal section through a strobilus at this period (August 12), showing the overlapping sterile bracts and the beginning of stamineal primordia. A remarkable development of the pith region of the axis below the staminate por-

tion of the strobilus, with its investing vascular cylinder, may be observed, apparently an important storage region for the strobilus.

STAMENS.—At the stage of the stamineal primordia observed August 12, there is no evident differentiation of tissues (*fig. 8*), but early in September the young sporangia become distinct, the sporogenous tissue being represented in each case by a single primary sporogenous cell. At this stage the further development of the young sporangia differs. Seven sporangia are seen in the primary sporogenous cell stage, three adaxial and four abaxial (*fig. 10*), radially arranged about the central axis as are the five or more sporangia in the allied Taxus. The four abaxial sporangia develop in the usual way, and become the pendent abaxial sporangia characteristic of Torreya. The three adaxial sporangia, however, do not develop further, the primary sporogenous cell not dividing, and its nucleus showing signs of disorganization (*fig. 9*). The disorganization continues until it involves all the cells separating the three adaxial sporangia, which are thus replaced by a single large flattened cavity, which becomes a resin cavity. Intermediate stages were found in which the three sporogenous regions were still distinct (*fig. 10*). In *fig. 11* (October 21) is shown a median longitudinal section through a stamen, in which the large resin cavity is seen above and the normally developing sporogenous tissue below. As a result, the mature stamen of Torreya is characterized by four abaxial sporangia and a large adaxial resin cavity.

In one instance the two lateral sporangia were smaller than the middle ones (*fig. 10*), suggesting a tendency to still greater reduction in the number of sporangia. Accordingly *Pinus Laricio* was examined, and two resin cavities were found related to the two sporangia exactly as the two lateral sporangia of Torreya are to the middle ones; and in early stages the tissue on the sites of these two resin cavities of Pinus resembles that of sporangia. It is interesting to note that in *T. californica* Miss ROBERTSON (8) found occasional stamens bearing six or seven mature sporangia, indicating that in these cases some or all of the usually abortive sporangia reached maturity.

There is evident a tendency to reduce the number of functioning sporangia by abortion, a reduction that has proceeded farther in Pinus than in Torreya; and in the latter farther than in Taxus. That

the cavities formed by the breaking down of young sporogenous and adjacent tissue should become resin cavities in conifers is to be expected.

It was only in the abortive sporangia of Torreya that stages were found indicating the history of the sporangium up to the primary sporogenous cell stage. For example, from *fig. 9* it seems evident that there was a single hypodermal archesporial cell, which at this stage had given rise to two layers of wall cells and a single primary sporogenous cell. In the mature sporangium there are three or four wall layers. The epidermis contains numerous stomata, and its cells become prominent and have thickened walls. The sporangia are bluntly four-angled from pressure, and the epidermal cells at the angles are much larger than elsewhere.

MALE GAMETOPHYTE.—We secured no stages between the very young sporangium and the shedding of the pollen, which occurs late in March and early in April. Miss ROBERTSON (8) has observed the mother-cell stage and the formation of tetrads in *T. californica*.

In germination the microspore of *T. taxifolia* cuts off no prothallial cell, a feature common to all the Coniferales except Podocarpeae and Abieteae. After the first division the generative and tube cells are distinct and separated by a very delicate wall or membrane. The tube nucleus is sometimes spherical, but more often amoeboid (*fig. 12*).

Early in April the binucleate pollen grains, rich in starch, were found resting on the nucellus (*fig. 19*); and at the end of June micropyles were found full of pollen grains, most of which had sent out no tubes, but were still full of starch, nucleate, and apparently alive.

As fertilization occurs about the middle of August, active pollen tubes occupy the sterile cap of the nucellus about four months, and their behavior is exceedingly variable. They may advance towards the embryo sac rapidly, reaching it at a very early stage, as early as June 21, when the endosperm consists of only sixteen to sixty-four parietally placed free nuclei (*figs. 14* and *15*); or they may advance slowly, being found at all stages of progress at the same date. They may advance so directly that the tube resembles a straight cleft through the nucellar tissue to the sac, or they may pursue a remarkably devious course. In one case a tube passed directly half-way

down the nucellar cap, then advanced spirally downward and outward until it reached the peripheral cells of the nucellus, and after destroying several of these it turned abruptly inward, penetrated the nucellus at the level of the archegonium, crossed the top of the endosperm, and discharged its contents into the archegonium on the farther side. In another instance, such a pollen tube had entered the inner integument and destroyed some of its cells before turning back into the nucellus. It is very common for the pollen tube to push into the sac at its free nuclear stage, making a deep invagination, often to the middle; from this pocket the tube turns back again into the nucellus. It is of interest to note in this connection that the usually solitary archegonium is never centrally placed in the endosperm, and the pollen tube enters the sac to one side of it (*fig. 16*).

In all the wanderings of the pollen tube, the body cell, stalk nucleus, and tube nucleus are conspicuous. The division of the generative cell was not observed, but that it occurs very early in the development of the tube is evident. The body cell is relatively very large, with a conspicuous nucleus and investing cytoplasm, and was always found consorting closely with the stalk and tube nuclei (*figs. 13* and *14*).

The division of the body cell just before fertilization results in unequal male cells (*fig. 23*), almost exactly resembling those of Taxus. It is not a case of the extrusion of one nucleus from the common cytoplasm, as observed by COKER (2) in Podocarpus, but the cytoplasm is unequally divided, so that there are two distinct and naked male cells very different in size. The whole cavity of the pollen tube surrounding the cells and nuclei is rich in starch and other food materials (*fig. 13*).

A consideration of the time involved in these various events shows that a period of about fifteen months elapses between the first appearance of the microsporangiate strobilus and fertilization, divided as follows: June, first appearance of strobilus; August, first appearance of stamineal primordia; September, distinct differentiation of sporangia; April, shedding of spores; August, fertilization. The strobilus was first observed in July, but in such a condition that it must have been evident in June, if not earlier. In comparing this schedule with that given by Miss ROBERTSON (8) for *T. californica*, it is evident

that the sporangium in both species passes the winter in the mother-cell stage, but that the subsequent stages appear earlier in *T. taxifolia* growing in its natural habitat than in *T. californica* growing in England. For example, in the latter case the reduction division takes place about the time that *T. taxifolia* sheds its pollen, and pollination in *T. californica* does not seem to occur until late in May or early in June.

OOGENESIS.

STROBILI.—The ovulate strobili are borne in the axils of the lower leaves of short young shoots (*fig. 2*). They usually occur in pairs upon a very short axillary branch, usually one pair, frequently two pairs, very rarely three pairs appearing upon a single shoot. A cluster of two to six strobili, therefore, appears near the base of the strobilus-bearing shoot, the upper pairs never maturing, usually one and sometimes both strobili of the lowest pair producing the large plum-like seeds (*fig. 3*). The strobilus is a very simple one, consisting of four enveloping bracts and a single terminal ovule with two integuments (*figs. 17* and *18*), the outer one often called an arillus because it ripens fleshy. The whole structure resembles a simple ovulate flower with a perianth of four bracts, which perhaps deserve to be called a perianth as much as the so-called perianth of Gnetales; but it is none the less evident that they are the sterile bracts of a much reduced strobilus.

The strobili were first seen July 26, at which time the growing point, enclosed by the bracts, was composed of entirely homogeneous tissue, showing no differentiation as an ovule (*fig. 17*). No subsequent stages were found until April 7 (*fig. 18*), when the mother-cells were in synapsis (*fig. 20*); and it seems probable that the winter was passed in the mother-cell stage. At this time the integuments are entirely free from the nucellus, appearing to arise from the base of the ovule. Soon, however, extensive intercalary growth below the mother-cell becomes evident, the ovule being greatly elongated and broadened below, the original free nucellus with its integuments forming only the tip. This growth continues throughout the season of fertilization and the following one; and OLIVER (6), who has described this intercalary growth in *T. nucifera*, estimates that in that species in the maturing seed the original nucellus with its free

integuments represents only one-twentieth of the entire length of the seed. The characteristic structures of the integuments are continued as two distinct peripheral layers of this large mass of additional tissue, and the tissue within these layers may be taken to represent in a similar way the downward extension of the nucellus. It is this additional nucellar tissue that the endosperm chiefly invades, giving rise to the phenomenon of "rumination," to be described later. OLIVER (7) has also described fully the course of the vascular strands in the ovule of certain species of Torreya, a description which seems to serve as well for *T. taxifolia*.

FEMALE GAMETOPHYTE.—The mother-cell is solitary and with no differentiation of a nutritive mechanism about it, such as appears in connection with the "spongy tissue" of Pinus, and in all the Pinaceae investigated. In Torreya it is directly in contact with the cells that are resorbed, without any intervening digestive layer (*fig. 20*). Since this is true also of Podocarpus (2) and Taxus (10), it suggests the possibility that Taxaceae in general may be characterized by the absence of a special digestive layer about the mother-cell.

The reduction division was not seen, but a more or less complete tetrad is formed, as observed by Miss ROBERTSON (8) also in *T. californica*.

The germination of the megaspore begins with the usual free nuclear division, the nuclei being in the parietal position when only sixteen to thirty-two in number (*figs. 14* and *15*). The interior of the sac contains cytoplasmic material, much less dense than the cytoplasm of the parietal layer, and also some reserve food. In this early few-nucleate stage of the endosperm there is always an appearance suggesting that the sac has sent a beak-like projection, containing a nucleus, upwards into the nucellar tissue (*fig. 15*). After a careful comparison of the position of this apparent projection in reference to the surrounding parts with that of the megaspore, it seems that the "projection" is the original site of the megaspore, and that the appearance of a projection is due to the fact that the sac has encroached almost exclusively upon the chalazal tissue. This conspicuous beak, containing one of the parietal nuclei, often appears close to the tip of an advancing pollen tube, and suggests a possible explanation of the peculiar behavior ascribed to the archegonium

initial of Tumboa. Inasmuch as the archegonium initial of Torreya often occupies this beak, the suggestion becomes still more pertinent (*fig. 21*).

The formation of walls in the endosperm was not observed before July 1, and in several instances they did not appear for a month later. When wall-formation began, repeated countings showed 256 free nuclei, which seems to be a very common limit of free nuclear division among gymnosperms.

Since fertilization was observed August 12, it is evident that the archegonium is developed very early in the history of the gametophyte. In fact, as soon as the very small sac is filled with extremely delicate tissue the archegonium initial becomes evident. It does not seem possible for archegonia to appear any earlier, for the initials are organized as soon as the free nuclear stage has passed. In Torreya, therefore, nearly all of the endosperm, which becomes an extensive tissue, develops after fertilization.

The single archegonium initial is always to one side of the central axis (*fig. 16*), often occupying the "beak" referred to above, and so projecting above the endosperm (*fig. 21*). A neck cell is cut off and divides anticlinally, forming a two-celled neck (*fig. 22*), the usual limit of neck-formation among gymnosperms. In fact, it is only among Podocarpeae and Abieteae that a more extensive neck is usually formed, consisting of more than one tier of cells, unless the somewhat anomalous neck of Ephedra be included. The fact that there is variation in the number of neck cells in the same form (two to twenty-five in Podocarpus), and that as a rule necks are destroyed as soon as formed by the growth of the central cell and pollen tube (*fig. 23*), suggests that their extent depends somewhat upon the approach of the pollen tube, which usually checks neck formation early, but sometimes permits it to become more extensive. In *T. californica* Miss ROBERTSON (9) has found that the archegonia are usually three in number, ranging from two to five, and that the necks consist of four or six cells.

The central cell enlarges rapidly, no jacket-layer being evident until after fertilization, and even then it is weakly organized (*fig. 25*). The nucleus is spherical and lies near but not against the neck cells, more nearly resembling an egg nucleus than in any gymnosperm

we have observed (*fig. 22*). We could not detect the formation of a ventral canal cell or nucleus, or anything that stood for such a structure at later stages. A ventral nucleus was expected, for a distinct ventral canal cell among Coniferales seems to be restricted to the Abieteae and does not always occur in them, and there seemed to be no excuse in our preparations for missing it. We are fully aware that all previous negative evidence as to the occurrence of at least a ventral nucleus in archegonium-forming gymnosperms has proved to be deceptive, but a study of the behavior of the central cell of Torreya, from the formation of the neck cell to fertilization, not only failed to show any indication of division but suggested that it may not occur. In *T. californica* a spindle seen twice in the central cell was interpreted by Miss ROBERTSON (9) as representing the "cutting off" of a ventral nucleus, but no other traces of it could be found.

In the single case in which two archegonia were observed, they were at opposite sides of the gametophyte, with the tip of a pollen tube between them.

At the time of fertilization the gametophyte contains 400–800 cells, with extremely thin walls and scanty cytoplasm (*fig. 23*). The only differentiation observable is the abundant accumulation of reserve food in the peripheral cells of the antipodal region. The whole mass of endosperm at this period usually measures 20 by 30μ; while in the mature seed the endosperm mass is ordinarily about 20^{mm} long by 14^{mm} at its widest part, and all of it surcharged with starch and other food materials. The food material is particularly conspicuous in a broad central band extending from the advancing tip of the embryo and widening to the antipodal end of the sac. *Fig. 5* shows the longitudinal extent of the band, and *fig. 4* its cross-section. The peculiar behavior of the endosperm after fertilization will be considered under the discussion of the maturing of the seed.

FERTILIZATION.

The forcible discharge of the contents of the tube may be inferred from the vacuole-like appearance in the center of the egg, produced by the inrush (*figs. 24* and *25*). The male nucleus in its cytoplasmic sheath passes through the cytoplasm of the egg and comes in contact with the egg nucleus. The male cytoplasm becomes closely appressed

to the surface of the female nucleus, slips from its own nucleus, and was observed extending over fully two-thirds of the female nucleus (*fig. 24*). This behavior of the male cytoplasm has been observed by COKER (3) in Taxodium and by Miss ROBERTSON (9) in *Torreya californica*. The male cytoplasm of *Torreya taxifolia* is sharply differentiated by staining from the cytoplasm of the egg, and undoubtedly completely invests the fusion nucleus. The appearance of a similar mass of cytoplasm investing the free nuclei of the first division (*fig. 25*), and continued in the second division in connection with wall-formation (*fig. 26*) suggests the possibility that the male cytoplasm may remain differentiated through more than one cell generation. Near the neck end of the archegonium nuclei are evident, which seem to be the stalk and tube nuclei and the other male nucleus with its investing cytoplasm (*fig. 24*).

EMBRYO.

Soon after fertilization the first division of the egg nucleus was observed (*fig. 25*), and almost immediately the second division follows, giving rise to four large free nuclei almost filling the egg (*fig. 26*), one nucleus in the base of the egg, the other three in a plane above. At this time wall-formation occurs, the cytoplasmic radiations which precede it being very evident (*fig. 26*). Two weeks later the egg is completely filled with a proembryo consisting of twelve to eighteen cells (*fig. 27*). This complete filling of the egg by the proembryo is remarkable among Coniferales, having recently been observed also by LAWSON (4) in Sequoia, but as yet not recorded in other genera. In Torreya, at least, this fact seems to be related to the relatively small size of the egg, the very large nuclei, and the early appearance of walls.

The cells of the proembryo at this early stage are distinctly in three tiers; that nearest the neck of the archegonium comprising five or six cells and forming the primary suspensor tier; the middle tier, comprising five or six cells and forming the secondary suspensor tier; and the lowest consisting of a single cell which ultimately contributes to suspensor-formation and forms the embryo. The inequality in the number of cells entering into the tiers seems to be characteristic of Taxaceae. In Podocarpus COKER (2) found the three tiers made up

of eleven cells in each of the upper two and one in the lowest; and a similar but less striking inequality is to be observed in Taxus. Occasionally in Torreya other divisions may occur, giving rise to approximately four tiers and a proembryo of about eighteen cells; but no other division occurs until the following spring, the winter condition being a proembryo of three or four tiers of cells as described above.

In the following season the suspensor develops and the embryo is formed, along with the characteristic "rumination" of the endosperm and the development of the testa. The first indication of change from the winter proembryonic condition is the elongation of the primary suspensor cells (*fig. 29*); a little later this is shared by the secondary suspensor cells; and this is followed by the elongation of the third tier, if four tiers are formed. In the meantime the terminal cell has begun a series of rapid divisions, resulting in a cylindrical mass of meristematic tissue, much as LYON (5) has described in the case of the embryo of Ginkgo. This meristematic cylinder advances gradually into the endosperm, its basal tiers of cells successively contributing to the suspensor elongation. Thus in the formation of the suspensor there seems to be developed what may be called a wave of elongation, beginning with the uppermost tier of the proembryo and extending gradually downward, tier after tier, until it includes the upper region of the meristematic cylinder formed by the terminal cell. This same phenomenon is very evident also in Thuja.

After the meristematic cylinder has advanced into the endosperm and has become prominent, the growing points are organized; the two cotyledons presently becoming beautifully crescentic in outline and completely surrounding the stem-tip; and the root-tip being organized deep within the meristematic cylinder.

In several instances a number of small embryos were observed imbedded in the endosperm about the suspensor region of the normal embryo. Our material did not permit any determination of their origin, but they resemble the proembryo of the normal embryo, and are developed while the latter is in its second season's growth. After the pollen tube has reached the archegonium, the endosperm grows up around it (*figs. 23* and *24*), so that the tube lies in a cup-shaped depression. After fertilization, the rim of this endosperm cup con-

tinues growth and gradually incloses the fertilized egg, in most cases forming quite an elongated beak above the embryo. Later many of these cells round off, forming a loose tissue, and it is among these rounded-off cells that the feeble accessory embryos are produced. Whether these have been developed apogamously from the endosperm cells, or have budded from the suspensor cells can only be conjectured. In any event, they might develop further if there was any failure in the development of the normal embryo.

The time involved in the series described above, that is from the first appearance of the megasporangiate strobilus to the maturity of the seed, is about thirty months, distributed as follows: June (?), first appearance of the strobilus; April, mother-cells in synapsis; August, fertilization; October, proembryo of 12 to 18 cells (winter condition); following season, development of embryo, "rumination" of endosperm, and development of testa; October, fall of seed.

MATURING OF SEED.

The outer integument and its histological continuation about the ovule develops a thick fleshy coat containing very numerous large resin cavities, and completely inclosing the structures within (*figs. 4* and *5*). This fleshy coat gives to the mature seed the appearance of a plum (*fig. 3*), as in the seeds of Cycads and Ginkgo. Within the broad band of resin cavities, near the inner limit of the integument, two conspicuous vascular strands occur, directly opposite one another (*fig. 4*). These are the main strands of the very characteristic vascular system of the ovule described by OLIVER (7).

The inner integument early differentiates into two distinct layers, a differentiation just as evident in Cycads and Ginkgo. The outer layer forms the stony coat, and the transformation from soft to very hard tissue begins after the embryo and endosperm have completed their development. The hardening begins at the apex of the ovule, and on account of resistance to stains appears under low power as a clear band (black in *fig. 5*). The hardening band gradually extends downwards through the relatively very short integument, and differentiating as a distinct layer in the much larger mass of tissue below completely invests the ovule within the fleshy coat. Protoplasmic connections between the cells of the stony coat and striations in the cell walls are unusually clear.

The inner layer of the inner integument comprises several layers of thin-walled cells, but beyond the integuments it is not histologically differentiated as a layer distinct from the tissue within. Accordingly, through the great bulk of the seed this layer may be neglected, and the whole mass of tissue within the stony layer and outside of the embryo sac will be spoken of as nuclear tissue or perisperm.

The behavior of the endosperm is peculiar, resulting in what is called "ruminated endosperm," a phenomenon peculiar to Torreya among gymnosperms, and commonly illustrated by the nutmeg. "Rumination" of endosperm proves to be a misnomer, for the endosperm is always the successfully aggressive tissue in developing this condition. The perisperm continues to grow throughout the maturing of the seed, and the final condition results from what might be called the struggle of two growing tissues that have been abutting upon one another through their whole period of growth.

In ordinary seeds the endosperm invades the surrounding tissue more or less uniformly; in the case of Cycads and Ginkgo, for example, obliterating most of the perisperm. In Torreya, on the other hand, the invasion by the endosperm is irregular in the extreme. It is in the season after the proembryo has been formed that the active invasion of the perisperm begins. The extension of the endosperm into the tip of the nucellus above the sac proceeds in the usual way, obliterating all of it except a few peripheral layers of cells. This uniform invasion seems to be due to the fact that in this apical region (the original nucellus) the perisperm is not growing actively if at all. Below this small region at the tip, however, the perisperm is very active and evidently resists disintegration much more at certain points than at others. As a consequence, the perisperm becomes eroded by the irregularly advancing endosperm, and is left in the condition of a much dissected coast-line (*figs. 4* and *5*). To the casual observer this results in an appearance suggesting that the endosperm is being invaded by plates of perisperm, but this is no more true than that the promontories of a dissected coast-line are advancing into the sea. The suggestion of an invading perisperm is further strengthened by the fact that within the perisperm bordering the endosperm a dark brown and finally black band of cells is developed, due to abundant food storage (*figs. 4, 30, 31*), but this really recedes as the endosperm advances.

A cross-section of the mature seed always shows a definite and deep constriction of the endosperm in the center, exactly opposite the two opposed vascular strands that run up on each side of the seed through the inner part of the outer integument (*fig. 4*). This constriction is the cross-section of two opposite and deep longitudinal furrows in the endosperm, and it means that in this longitudinal plane the endosperm encounters the greatest resistance in invading the perisperm. This most resistant perisperm certainly seems to hold a very definite topographical relation to the principal vascular strands, and this relation may explain the resistance.

That endosperm is the aggressive tissue at every point, even at the region of most resistant perisperm, is evident for several reasons. In no case were the peripheral cells of the endosperm broken down; and in no case did there fail to appear one or two layers of disorganized cells of the perisperm in contact with the endosperm (*figs. 30* and *31*). In every case, also, the peripheral cells of the endosperm appeared active and very vigorous, and their different appearance in regions of more and less active encroachment is striking. In regions of active invasion the endosperm cells are radially elongated, and many of them are binucleate (*fig. 30*); while in regions of less active invasion the cells are more nearly isodiametric and rarely binucleate (*fig. 31*).

Another proof that endosperm is the encroaching tissue may be obtained from comparative measurements. At the times of fertilization the gametophyte usually measures 20 by 30μ. In the mature seed the ordinary length of the gametophyte is 20^{mm}, the greatest width being 14^{mm}, and the least (at the deep constriction opposite the vascular strands)) 1.5^{mm}. At this most resistant region of the perisperm, therefore, where it is hard to escape the conviction that the perisperm plate has cut the endosperm nearly in two, the endosperm has increased its diameter against the perisperm seventy-five times.

The best reason, however, for concluding that the endosperm is the invading tissue in this case is that this is always the behavior of endosperm; and it is singular that the old explanation of "rumination" was ever suggested. An examination of the nutmeg, the classic illustration of "ruminated endosperm," and of *Asimina triloba*,

showed that precisely the same explanation applies to them that we have given in the case of Torreya.

SUMMARY.

The staminate strobilus consists of a series of closely overlapping sterile bracts, in four vertical rows, completely enveloping the tip of the axis bearing numerous stamens. The large adaxial resin cavity that occurs in the stamen occupies the site of three abortive sporangia.

The male gametophyte has no prothallial cell, and the male cells are very unequal, resembling those of Taxus. The pollen tube is exceedingly variable in the rate and direction of its advance through the nucellar cap, sometimes pushing in the embryo sac while it is in an early free-nucleate stage.

The ovulate strobilus consists of four enveloping bracts and a single terminal ovule with two integuments. Extensive intercalary growth below the mother-cell forms the bulk of the mature ovule and seed. There is no organization of a special digestive layer around the mother-cell.

The solitary archegonium initial appears as soon as walls are formed, is always at one side of the central axis of the gametophyte, and forms a two-celled neck. The nucleus of the central cell was not observed to divide, nor could any trace of a ventral nucleus be found.

In fertilization the male cytoplasm invests the fusion nucleus, and seems to remain distinct until wall-formation at the four-nucleate stage of the proembryo.

In the development of the proembryo, four free nuclei appear before wall-formation, and the proembryo completely fills the egg, having no "open cells." A proembryo of twelve to eighteen cells is the winter stage. In the spring the suspensor is formed by what may be called a wave of elongation, beginning with the uppermost tier of the proembryo, and extending gradually downward, tier after tier, until it includes the upper region of the meristematic cylinder formed by the terminal cell.

Small embryos are formed during the second season in the suspensor region of the normal embryo; but whether they arise from prothallial or suspensor cells was not determined.

The "rumination" of endosperm, peculiar to Torreya among gymnosperms, arises from the extremely irregular encroachment of the endosperm upon the perisperm, the endosperm being resisted much more at certain points than at others. The same was found to be true of other "ruminated" seeds.

THE UNIVERSITY OF CHICAGO.

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EXPLANATION OF PLATES I–IV.

With the exception of *Plate I*, all figures were drawn with the aid of an Abbé camera lucida and reduced one-half in reproduction. Abbreviations are as follows: *br*, bract; *a*, primordium of stamen; *oi*, outer integument; *ii*, inner integument; *r*, resin cavity; *n*, nucellus; *pc*, pollen chamber; *s*, sporogenous cells; *tn*, tube nucleus; *g*, primary spermatogenous cell; *stn*, nucleus of stalk cell; *b*, body cell; m_1 functional male cell; m_2 functionless male cell; *hr*, haustorial region of female gametophyte; *nc*, nucleus of neck cell; *o*, egg; *end*, endosperm; *per*, perisperm.

PLATE A.

FIG. 1. Staminate branch; October 21, 1904. ×1.

FIG. 2. Ovulate branch; April 7, 1904. ×1.

FIG. 3. Mature seed; October 21, 1904. ×1.

FIG. 4. Cross-section of seed showing ruminated endosperm with storage region in center, seed coats, stored food in the perisperm, and resin ducts. ×3.

FIG. 5. Longitudinal median section through seed showing embryo, ruminated endosperm, and seed coats. ×3.

PLATE I.

FIG. 6. Transverse section through a staminate strobilus showing bracts and primordia of stamens; August 12, 1904. ×24.

FIG. 7. Longitudinal section through a staminate strobilus showing enveloping bracts, primordia of stamens, and storage region; the position of the bundles is shown by the dotted lines; August 12, 1904. ×24.

FIG. 8. Primordium of a stamen; August 12, 1904. ×460.

FIG. 9. Median section through an adaxial sporangium showing the disorganizing primary sporogenous cell and two wall cells; October 21, 1904. ×460.

FIG. 10. Cross-section of a sporophyll showing the three abortive adaxial and the three functional abaxial sporangia; October 21, 1904. ×47.

FIG. 11. Longitudinal section through a stamen showing early stage of the resin cavity above and a functioning sporangium below; October 21, 1904. ×255.

FIG. 12. Pollen grain showing primary spermatogenous cell and tube cell; April 7, 1904. ×1250.

FIG. 13. Tip of a pollen tube which has penetrated about half way through the nucellus; June 10, 1904. ×460.

FIG. 14. Tip of pollen tube in contact with the embryo sac; the female gametophyte is in the free nuclear stage and the nuclei are placed parietally; June 21, 1904. ×460.

FIG. 15. Embryo sac in free nuclear stage showing one of the nuclei occupying the place of the megaspore mother-cell; June 10, 1904. ×185.

FIG. 16. Pollen tube in contact with the endosperm; an archegonium is at the left of the tube; July 26, 1904. ×255.

PLATE II.

FIG. 17. Young ovulate strobilus showing enveloping bracts, inner integument, and nucellus; July 26, 1904. ×47.

FIG. 18. Ovulate strobilus showing bracts, integuments, nucellus with rudimentary pollen chamber, and megaspore mother-cell; April 7, 1904. ×24.

FIG. 19. Tip of nucellus with pollen chamber containing a microspore; April 8, 1904. ×220.

FIG. 20. Megaspore mother-cell in synapsis; April 7, 1904. ×460.

FIG. 21. Micropylar end of female gametophyte with archegonium initial projecting into the space formerly occupied by the megaspore mother-cell; July 26, 1904. ×460.

FIG. 22. Archegonium consisting of two neck cells and central cell; the nucleus of the central cell has rounded out, and is passing downward to the center of the cell and taking on the appearance of an egg nucleus; July 26, 1904. ×460.

FIG. 23. Median longitudinal section of female gametophyte showing egg, remains of a neck cell, and antipodal haustorial cells; the tip of the pollen tube in contact with the egg contains stalk and tube nuclei, functional and functionless male cells; the upward growth of the endosperm cells forms a sheath around the pollen tube; August 12, 1904. ×460.

PLATE III.

FIG. 24. Fertilization; the male nucleus is in contact with the egg nucleus; the cytoplasm of the male cell is closely applied to the egg nucleus; the functionless male cell, and tube and stalk nuclei are in the upper part of the egg cytoplasm; the cavity in the egg cytoplasm is caused by the inrush of the contents of the pollen tube; August 12, 1904. ×460.

FIG. 25. Two-celled proembryo; the dense cytoplasmic mass surrounding the nuclei is probably in greater part derived from the male cytoplasm; August 27, 1904. ×460.

FIG. 26. Four-celled proembryo; walls coming in; August 12, 1904. ×460.

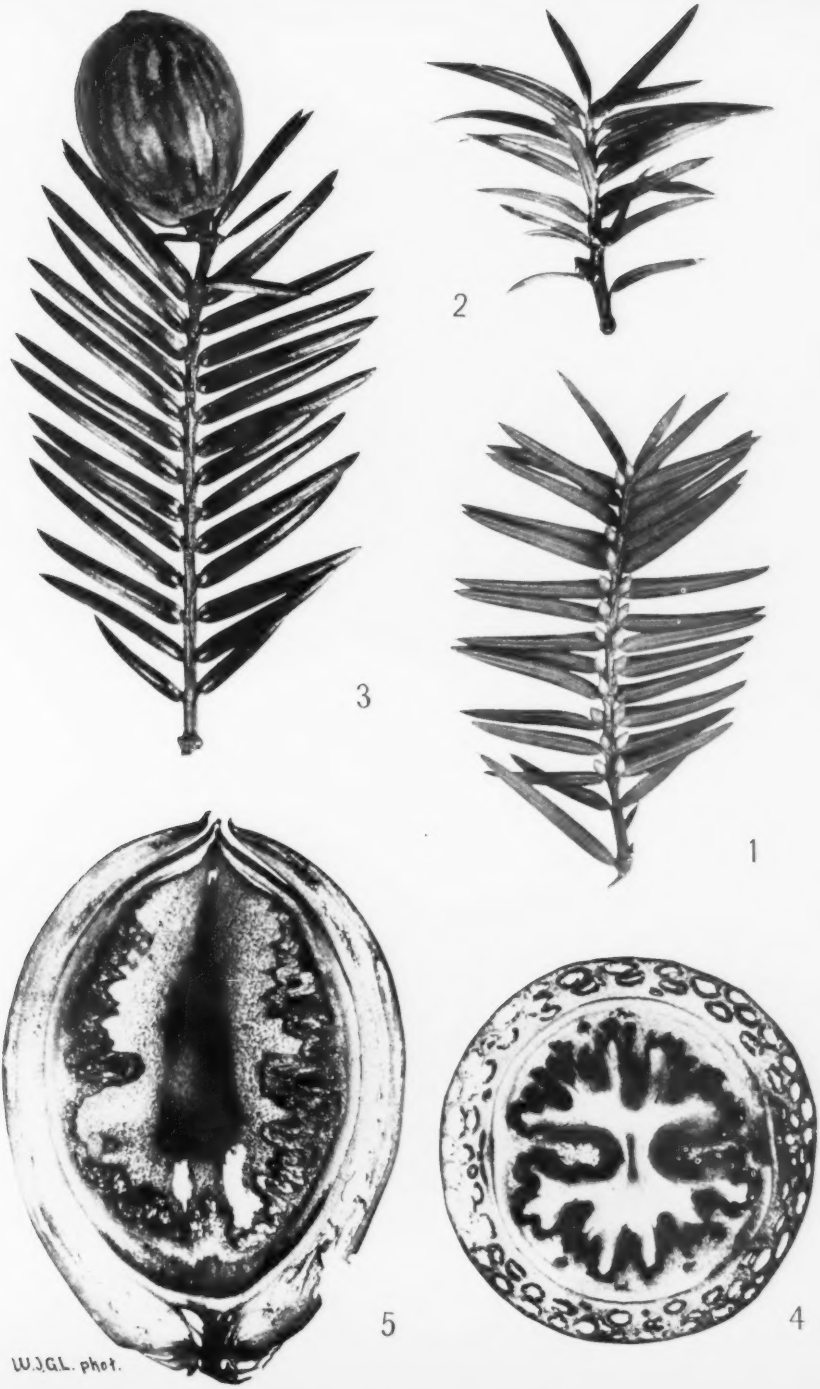
FIG. 27. Proembryo shortly after walls are laid down; the proembryo passes the winter in this stage; August 27, 1904. ×460.

FIG. 28. Cross-section through suspensor cells; September 12, 1904. ×460.

FIG. 29. Proembryo showing elongation of suspensor cells; April 7, 1904. ×460.

FIG. 30. Endosperm cells encroaching on perisperm; August 12, 1904. ×640.

FIG. 31. Endosperm cells which have ceased to encroach on perisperm; August 12, 1904. ×460.



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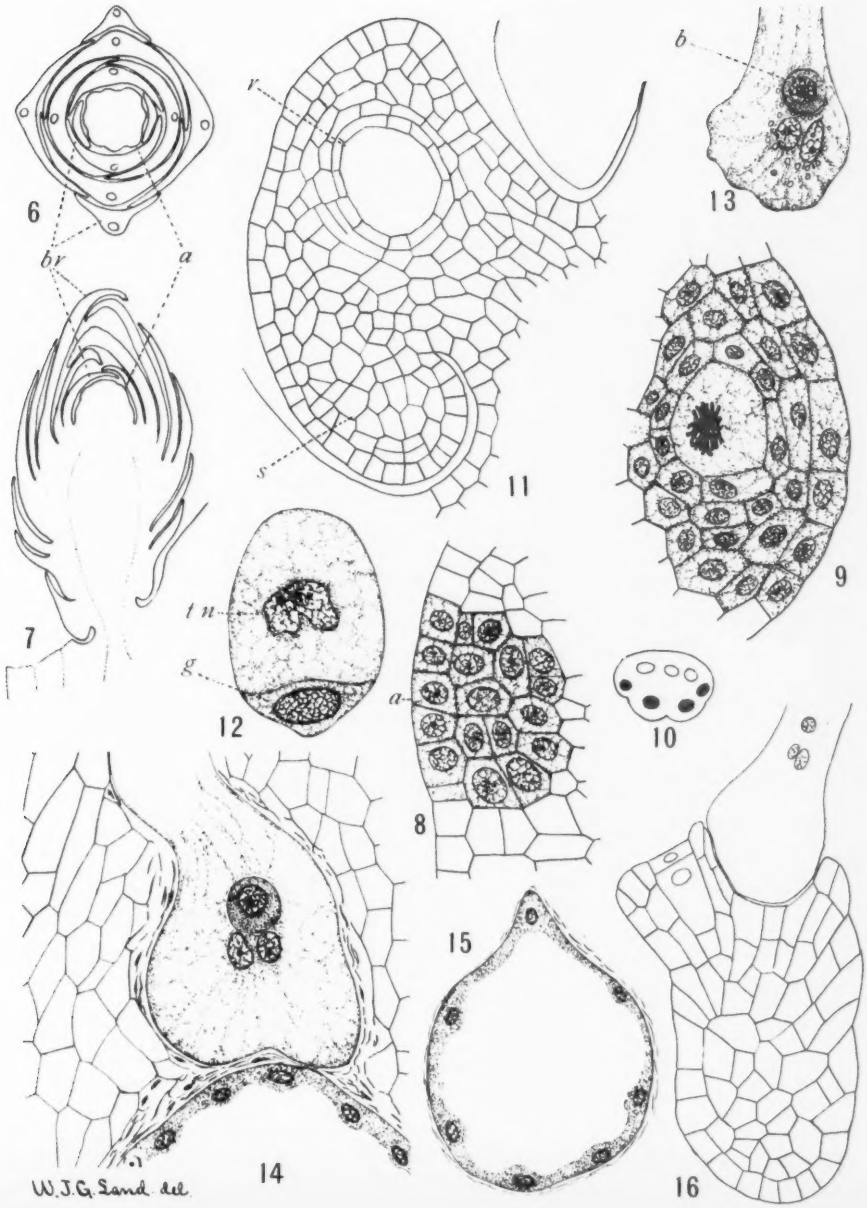
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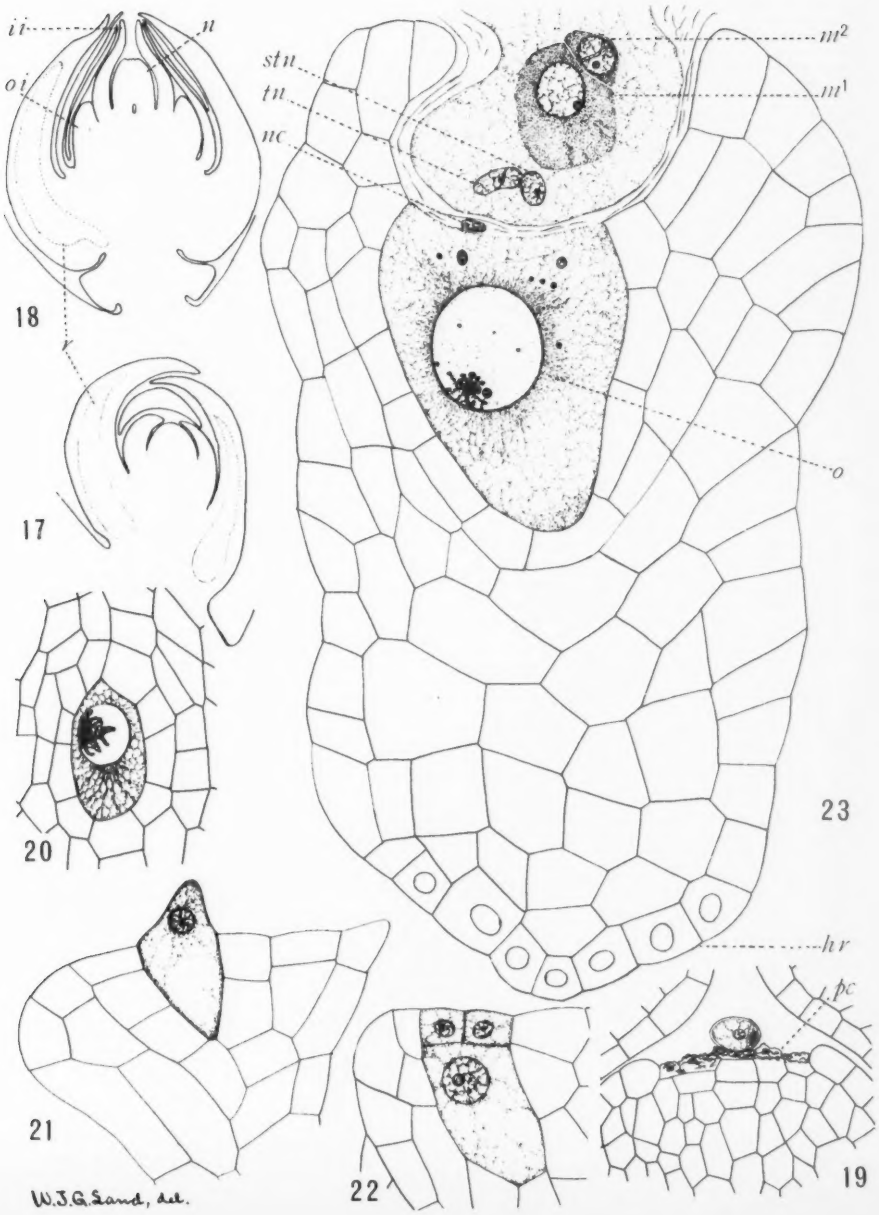
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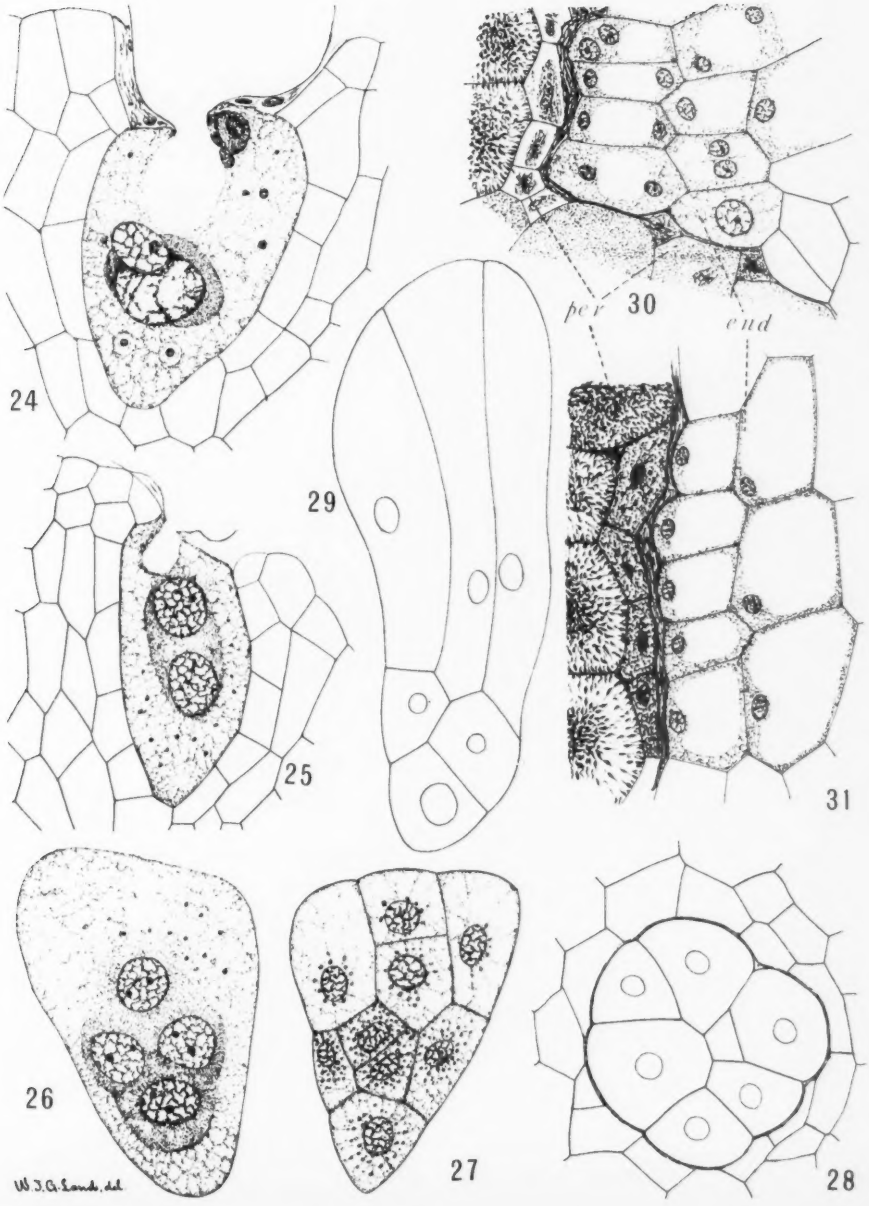
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THE PRINCIPLES OF PHYTOGEOGRAPHIC NOMENCLATURE.[1]

PEHR OLSSON-SEFFER.

THE confusion prevailing within the nomenclature of phytogeography has of late been repeatedly brought up for discussion. A unanimous opinion exists as to the disadvantages resulting from the present chaotic terminology. Such a diversity of ideas prevails that every writer is obliged to explain in what sense he has used a technical term, and if he omits an explanation we are often left in doubt as to the interpretation of the expression used. An agreement has to be arrived at, sooner or later, and the sooner there is an end to the present disorder, the better for the progress of phytogeography and all concerned.

This science is still in its infancy and very few of its doctrines are settled beyond doubt. We meet with contradictory views at every step. Sweeping generalizations, often based upon very imperfect observations, and described in vague and uncertain terms, full of ambiguities, threaten the development of this important science. Its advancement and success depend upon well-settled methods of investigation and description. The necessity of adopting a nomenclature similar to that of other descriptive sciences is obvious. The prevalent fault of which we complain is not the absence of names and technical terms, but of the defective definition of the terms now in use. It has always been much easier to offer censure than to correct mistakes, easier to state evils than to relieve them. My object in this paper is not to give any proposals as to the detailed arrangement of phytogeographical nomenclature, but to discuss some of the general principles which ought to prevail in any attempt to revise the nomenclature so as to meet the present demands of the science. I have elsewhere, in papers appearing simultaneously with this, drawn attention to the terminology of certain phytogeographical phenomena.

[1] Read before Section G of the American Association for the Advancement of Science, Philadelphia meeting, December 30, 1904.

Since the appearance of the papers of WARBURG, FLAHAULT, NILSSON, and CLEMENTS on this vexed question of nomenclature, it could have been expected that some discussion would arise, but instead it seems as if phytogeographers were content with the opinions brought forward, although these are by no means harmonious. The object of plant geography is the study of the distribution of plants, and of the laws that govern this distribution, not wrestling with words nor philological hair-splitting. But it cannot be denied, as I have just said, and as is generally conceded, that this science needs uniformity of expression; how to obtain this is the problem.

The next international congress, to be assembled at Vienna in June 1905, is to take this matter under consideration. Some of the foremost phytogeographers of the world constitute a committee which is to make a report and submit certain proposals that may or may not lead to a solution of the problem. It is only the general principles, however, that can be laid down by any one botanist or any joint committee, because it is quite beyond the power of any one except the individual monographer to decide what expression may be necessary in his individual case. But so long as each one is allowed to do what he thinks is right, there will be no end of the present trouble. What we need is a good, clear system of wholesome general rules. The practical and gradual application of these must be left to the discrimination of the individual writers, who have to describe conditions essentially different in different cases. The reader is then the judge whether the writer has succeeded in his application of the rules, whether his terminology is correct or not. No permanent international committee is needed for the purpose of acting as a guardian or a court. If a good code of rules for nomenclature is laid down, it will be followed spontaneously by all writers of any consequence, without the fear of a court of judges. If the code is a bad one, it is not worth following, and will not be accepted in spite of any supervising committee, however great its authority. It must be remembered that no matter from what association or individual such a law of nomenclature has emanated, it is and will always be temporary. It is impossible to determine upon any rules that will stand for all time, because what meets the present needs will most likely not satisfy the next generation. How long, then,

shall a writer consider himself bound to follow these rules? They will certainly have to be changed from time to time. It is especially impossible to decide upon the fixity of special terms, because a name may be founded on ideas, which, in the course of time, owing to the progress of science, will be shown to be incorrect. No such rules as are applicable to the nomenclature of taxonomy can be brought into effect in regard to a system of terminology.

The law of priority, which is the first principle in the nomenclature of systematic biology, cannot be strictly adhered to in this connection. It has been proposed by CLEMENTS[2] that "priority of term and of application is to be regarded as the fundamental principle of phytogeographical nomenclature." ENGLER, who must be considered as better qualified than most men to judge in such a matter, in a footnote to CLEMENTS' article expresses strong objection to the introduction of a law of priority in phytogeography. The acceptance of such a law would lead to the retaining of names which are neither expressive of the idea they represent nor suitable in other ways. If an absolute rule of priority is maintained, how are we to arrange for the retaining of names that originally expressed ideas now considered as false? Every terminology shows traces of such names. What conception in that case shall represent the type of the systematist and bear the old name? It can be seen at a glance that the rule of priority is not practicable here as it may be in taxonomic nomenclature.

The question whether to retain an old term which is not good, or to abolish it and substitute a new name, will always be difficult. If a free hand is given, phytogeography will have a heavy load of useless synonyms that always will act as a drag on true science, and create much more confusion than exists now. If on the other hand any restriction can be brought about, it must be to the effect that priority should be conceded to such a name only as has been properly defined in a work accessible to scientists. To impose new names needlessly upon previously named conceptions will always be considered bad form, and a general consensus of opinion prevails as to this habit. Suddenly introducing a large number of new terms into

[2] CLEMENTS, F. E., A system of nomenclature for phytogeography. Beiblatt Bot. Jahrb. 70: — 20. 1902.

a new science is the best way to stifle it. It is with great hesitation that a new term should be coined, and it needs in each case a specialist to decide as to the necessity for such an action. Good and forcible reason should always be shown why an old term is not sufficient to indicate the conception that is to be described. It should never be forgotten in rejecting already established names that there is a possibility that the new term may meet a similar fate from a later writer. If that were always borne in mind, perhaps writers would think twice before entering the arena as name-makers. The true test of the quality of a term is generally the time it is able to exist, provided the conception as such remains unchanged. Not infrequently, however, names are introduced into a science—phytogeography not excepted—for speculative theories and ideas, upheld and supported by facts which are consciously or unconsciously misinterpreted to fit preconceived notions. In other cases new terms are proposed for already named conceptions, because of ignorance on the part of the writer. We may here remember what DECANDOLLE says in his *Phytographie:* "the perfectly honest and right-minded botanist may sometimes have failings. He may neglect to cite his predecessors, or cite them inexactly, either from negligence or from want of literary resources. The latter case may be deemed a misfortune and no fault." "But," continues DECANDOLLE, "if he has not the necessary books within his reach, why not go where they are and consult them? Or if unable to do that, why need he publish?" Where a writer may have enriched the nomenclature with a new term for which no need existed, the application by subsequent writers of the rule of priority is to be recommended. If the term in question be introduced by a writer who enjoys real or affected authority, and his term is accepted upon such motives by a thoughtless multitude, it will naturally sooner or later be suppressed or ignored and finally disappear.

When we undertake to revise nomenclature and find terms the meaning of which is doubtful, the only proper way out of the dilemma seems to be to ascertain the conception given to such terms by the original proposer. If the term cannot be used in that sense it should be discarded. We have a good illustration of this in the much mistreated term "phytogeographic formation." It was originally proposed

by GRISEBACH (1838) to designate an aggregation of plants characterized by a dominant species. But, as his examples show, GRISEBACH considered his formations as having a certain physiognomic aspect, and when in 1872 he moderated his conception of the term formation to an association characterized by a physiognomic type instead of by a dominant species, he only more pronouncedly brought forward the conception of a physiognomic unit. Leaving aside all the various uses of this term by later writers, we have to consider whether the original conception of GRISEBACH of a general plant-topographic or physiognomic unit, such as forest, steppe, tundra, or prairie, can be retained in the light of modern investigations. If that is the case the name stands, if not it falls. I have endeavored to show, in a paper now in print, that we need the term formation in the sense of GRISEBACH. Did our limits allow, we might call attention to many other instances where we could clear up the muddy stream of phytogeographical names. One more example will suffice to show how this rule would work. The word zone is now used as a technical term in phytogeography to designate at least the following conceptions: the successive belts of vegetation on a mountain side, the horizontal climatic zones of the surface of the earth, the belts of vegetation surrounding a pool or succeeding each other on a shore, the submerged belts especially of marine algae, the layers in a fossil-containing deposit; in many local descriptions it is adapted for designating any convenient floral area delimited from others; and finally in anatomy the term "zone" is applied to any area distinguished in structure from its surroundings. That this multiform interpretation of the word zone needs adjustment is manifest. In the technical language of a science a term should have only one meaning. Nothing but confusion will come from the admission of enigmatic terms, and the clarifying process is therefore the one we expect the nomenclature of phytogeography will shortly be exposed to. If in regard to the term zone we follow the principle given above, we have to ascertain what author first introduced it as a technical word, and in what meaning it was used by him. In 1839 BOISSIER designated with this term the vertical belts of plants in mountains. In a corresponding sense it had been used for a long time previously in topography, as also FLAHAULT[3] mentions. The

[3] Projet de nomenclature phytogéographique. 1890.

term zone in plant-geography, therefore, should signify the successive stages of vegetation from the base to the summit of a mountain, and nothing else. It is true that WAHLENBERG[4] in 1812 designated these belts with the term *regio*, and if we followed the rule of absolute priority, this would be the correct term. *Regio*, however, was used long before WAHLENBERG'S time by botanical writers in the general sense of a geographical area of more or less definite extension, and so was zone. In this case we are confronted with two synonymous terms, and the only principle on which a decision can be based seems to be that of general usage. It must be admitted that it is an extremely difficult matter to lay down any rules that would take us out of dilemmas such as this. If it were possible to canvass the various authors to ascertain which term has been used more than the other to designate this special feature of mountain belts we are considering, it is very doubtful at what result we would arrive. Region, however, since MARTIUS used it in 1831 for a certain phytogeographical area, has generally been understood and adopted by the best writers for that purpose. FLAHAULT has made the relation and usage of these two terms, zone and region, clear by adopting them in the sense advocated above. If that is universally done, we have to find other appropriate terms for the various conceptions that often have been called zones. Nor need we take refuge to the method of making new terms in this case, for we only have to make a selection from the multitude of expressions already used, and in selecting we can make a choice that will serve in other languages as well as our own, and thus to some extent satisfy the call for an international nomenclature.

The first and most essential principle of nomenclature is clearness. To obtain this result, all the expressions used in technical terminology, whether they be old established names or newly coined ones, must be definite, concise, perfectly distinctive, and easily intelligible.

All names and terms are for the sake of convenience. In order to insure mutual intelligibility, greater precision, and clearness, it is imperative to avoid names that will create error or ambiguity. It is not inconceivable that the need of short compendious names and terms to denote phytogeographical facts or processes can be met

[4] Flora Lapponica. Berlin. 1812.

by individual monographers following certain general principles, which should be applied with all possible generality. *Festina lente* is the maxim into which we might condense the prevalent, but perhaps not yet outspoken condemnation of the tendency to drown our science in a torrent of unpronounceable so-called international terms, which cannot but embarrass the student, render the subject less accessible and more difficult to handle, and be exasperating to lovers of a clear, consistent, and uniform nomenclature.

Emphasis must also be laid upon the manner in which a term comprises the idea it is to convey to the reader. In systematic biology it is now held that a name need not contain any reference to the subject it represents, and may be wholly meaningless. This would hardly be convenient, however, in a system of terminology. The limitation of human memory makes it important that the term or name employed in a descriptive science should not be merely a name, but also associate in one form or another our thought with the subject we are discussing. In making new terms or in discriminating between already existing ones we should bear this in mind. It is just as easy to coin a name of this kind as it is to make a meaningless one. There might be a tendency to attribute too much importance to the meaning of a name, but all things considered it seems easier to remember a term that at once conveys to our mind the conception it stands for.

It has been recommended by several writers that we ought to avoid having names that are already used in geology or some other science nearly related to phytogeography. It stands to reason that such a course is neither absolutely necessary nor very advisable. Although we speak of stratification in connection with sedimentary processes in dynamic geology, it does not follow that the term stratification could not be used in plant geography to designate the division of a plant community into strata, without implying any ambiguity or causing any confusion. Objection has been made in regard to certain terms such as formation and province, the former word being used in geology, the latter in a political sense. If we were consistent, a great number of names which have been used for a long time in botany ought to be ruled out, because they are also used in zoology, or *vice versa*, as anatomy, cytology, heliotropism, parasitism. Any

small inconvenience that may result from this principle of ignoring the fact that a term is already established in another science would be counterbalanced by the appropriate use of similar terms to designate related phenomena in related sciences.

It is of importance in applying technical terms or inventing new names to take a broad view of the subject, and not use geographical terms, that generally refer to large areas, to signify local phenomena. We might mention as an example the use of the expression Austral zone for a phytogeographic area of North America. It has always been understood, however, that the term austral refers to the southern hemisphere, and it is as wrong to use the word in the way mentioned as it would be to apply its counterpart boreal to the northern part of Brazil or Australia. It would be greatly misleading if a botanist, say in Australia, would designate for instance the eastern coast region of that continent as the Oriental region.

When LINNAEUS brought about the reformation of systematic nomenclature he freed the names from the cumbrous descriptive phrases by assigning to each object a generic and a specific name. Similarly a concise mode of expression in phytogeography ought to be agreed upon, so as to save a great deal of verbosity which at present naturally must accompany an exact and complete phytogeographical description. The difficulty of presenting the results in a compact form would not be very much bettered, however, by adopting suddenly a number of new terms, because most likely the remedy would in that case be worse than the disease. It may be safely said that by instituting a uniform method of applying necessary terms, and by bringing such an agreement into universal practice a long step would have been taken towards establishing order.

The question of obtaining a nomenclature of an international character has been discussed to some extent. There can be no doubt as to the beneficial results that would follow the adoption of such names. The practicability of the application of any rule to that effect, however, seems somewhat doubtful. Be that as it may, we are justified, I think, in looking forward to some kind of tacit agreement in this case between plant-geographers of different countries.

Another question is how such international terms should be formed. WARBURG and CLEMENTS think that only Greek and Latin

can be used. FLAHAULT, NILSSON, WARMING, and ENGLER, among others, are of the opinion that vernacular names ought not to be excluded. While it seems absolutely imperative that in referring to plants we should use only the scientific name, it does not appear to be so overwhelmingly important to change all those terms of vernacular origin, which already are established in phytogeography, into quasi-international substitutes drawn from Greek or Latin. In the former case we have thousands of names, and consequently we use the accepted scientific names, which can be easily identified, instead of the vernacular, as the latter would surely give rise to confusion. On the other hand, the number of technical terms in phytogeography is fortunately not yet so great as to make the list a very voluminous one. Even if vernacular names are retained, or introduced to designate certain facts, this would not militate against a uniform nomenclature so long as the names are clear and do not give rise to any doubt as to their significance.

One fatal objection to a change into Greek-Latin of such commonly understood and accepted names as tundra, prairie, chaparral, scrub, savannah, and others, is that in spite of the adaptability of these ancient languages, it is impossible to translate these terms adequately, since the ancients did not have any conception of the ideas or facts these names represent, and any attempt to fabricate a modern name from the ancient languages to signify, for example, the formation known as the patana of Ceylon would be a failure, so long as we want the term to suggest to our mind the peculiar conditions that characterize this particular formation. If we consider the chief object of nomenclature to be to serve our convenience, I fail to see why the name patana would not be acceptable in any language, and thus be international. As a matter of fact, it is so already, and in all probability very few persons would approve of a Greek-Latin equivalent coined according to the principle of constructive naming. CLEMENTS, who is the principal advocate of the latter method, and who has augmented the labor of those who are endeavoring to find a way in the labyrinth of phytogeographical terms by proposing at least 500 new names, has given the name psilium to a prairie formation, deriving this "international" term from ψιλείου or ψιλά, bare, naked. Now this new name does not convey any idea of a prairie

to the reader because it can be applied as well to any treeless formation. Prairie, on the other hand, is a term well-known to every schoolboy the world over, and there is no need whatever to overload memory with a new name that serves no useful purpose. For the term "bad lands" of Nebraska CLEMENTS suggests hydrotribium, and for plants on that formation hydrotribophyta. Terms such as these are very expressive in a way, but they are certainly not an improvement. The English "bad lands" applied to this particular formation is widely known, it causes no ambiguity, and there would be no objection raised against its acceptance in French, German, or any language, but most people would certainly protest against hydrotribium. And still this last term can be pronounced, but what about ptenothalophyta, rhoium, ammochthophilus, proodophytia, mesochthonophilus, chosen at random from CLEMENTS' catalogue? The terms rolling prairie, rolling foothill, rolling downs, and so on, can readily be adapted in any language, and be just as characteristic as if we translated them into some more or less high-sounding name derived from the Greek word for rolling, or wheel, or ball, or some similar expression. In geology many characteristic words have been borrowed from the vernacular for technical use, as fjord, atoll, and canyon. Would physiography have been better off in regard to clearness and brevity of expression if names of mixed Greek and Latin origin had been invented for these conceptions, which had no equivalent in the language of the ancients? ENGLER, in the footnote to CLEMENTS' article already referred to, gives the following categorical judgment in this matter: "dass es sicht nicht empfielt, die volkstümlichen Bezeichnungen von Pflanzenformationen aus der pflanzengeographischen Literatur zu verbannen."

What has here been said may suffice to show that new names cannot be invented to advantage for features that already have well established and characteristic designations in the vernacular language of the country where they constitute a salient feature. Good common sense in this as in many other cases must be the guide in choosing technical expressions.

If a suggestion were offered as to the first step necessary in order to obtain uniformity, it would be that we have to decide about the various kinds of floristic, topographic, and ecologic units that can be

and are necessary to distinguish. It has been suggested[5] that the division of the vegetation into formations must be founded upon the concept of habitats. This principle is a good one, the only difficulty seeming to lie in the practical working of the rule. Any one conversant with the great variety of forms of habitat is aware that such a classification is no easy undertaking. In all attempts made the authors have decided for one or another environmental factor that has influenced the development of the formation, and consequently the classification has been more or less artificial. The task of identifying, classifying, and naming plant aggregations, or features of the vegetation, is extremely difficult because of the comprehensive data necessary to illustrate the complex factors influencing distributional phenomena. The use of one class of names that refer to habitat, however, are inevitable and absolutely necessary. For such terms we can turn to the vernacular language, which often possesses very expressive names that combine in one word the main features of environment. Together with the term formation as representing the large topographical units of vegetation such vernacular terms are very adequate. Let me give a few examples to illustrate this. The chaparral formation of California and southwestern United States generally is one of the most peculiar anywhere. There can be no doubt about the meaning and scope of the term, when the formation has once been clearly defined, because it has no counterpart in any other region of the world, although it certainly is paralleled in many places by related formations. The expression chaparral formation gives not only a general idea of the component plants, but it also includes a conception of the topographic aspect of the country where the formation occurs, and whose physiognomy it assists to mold. Still the term is strictly devoid of any reference to the dominant species concerned in the aggregation of plants in any part of the formation. Formational names should always be so. A formation can be subclassified into associations, and these into communities. The latter can be designated adequately by adding the suffix *etum* to the scientific name of the dominant plant after the method first suggested by HULT.[6] The limitations of this article do not allow me

[5] CLEMENTS, *l. c.*

[6] Försök till en analytisk behandling af växtformationerna. Medd. Soc. F. Fl. F. 8:1–155. 1881.

to enter into details with regard to this method of classification, which I have found works equally well in the arctic parts of Europe and in the Mediterranean countries; in the primitive tropical forests of Ceylon, northern Australia, and Polynesia, and in the semi-arid regions of New South Wales and Western Australia; in New Zealand and in California. I may say that in my work in these countries I have not found it necessary to introduce any new system of naming, but merely to coordinate and classify previously existing conceptions. And I firmly believe that this working out of the synonymy will be the only method by which a final agreement can be reached.

We have further to classify all the units of one kind or another into groups according to relationship, and to give names to them, availing ourselves as much as possible of terms already existing, the synonymy of which must be cleared up thoroughly. After laying down the general principles of nomenclature in the code to be recommended, we have to leave the application of these canons to the individual writers.

This should be the program for a permanent committee to be appointed by the next international congress. Let this body then publish the results of their work and submit them for leisurely consideration and discussion. When conflicting opinions, if there are any, have been expressed, and direct or circumstantial evidence has been brought in to illustrate and reinforce the various principles, it is time to settle the matter by adopting a general code of nomenclature. There can be no hope of getting any substantial improvement in existing conditions through any immediate action of the botanical congress, because of the great diversity of opinion and practice that prevails, and because no definite proposal based on facts and logical arguments has yet been held forth which could be made subject to a detailed criticism. Any proposition that presents principles or terms without proper and clear definitions can naturally not be considered.

The question may arise as to what constitutes a definite description. The degree of exactness and clearness of expression will naturally vary with the different authors, but so long as there remains any doubt as to the feature meant by the writer his term can hardly expect to be generally accepted.

Nomina nuda in the sense of systematic biologists appear not infrequently in phytogeographic literature, and it must always be considered as insufficient definition to supply merely a translation of a formational name, without giving a description sufficiently clear to remove every trace of doubt as to what the writer has described.

Whenever coining of pseudo-classical names is resorted to, it is to be expected that the author would at least take into consideration some degree of linguistic purity, besides the matter of precise meaning, because it is important that terms which are also to be spoken should be euphonious and in some harmony with the pronunciation.

In regard to the rules of coining new terms from Greek and Latin it has been claimed that the classical languages only should be considered. Rules of that kind are difficult to follow. In the real classical Latin, for example, the words are used in so many different ways that it will often be difficult to bring them into conformity with the primary rule of technical nomenclature that each idea should be represented by a single term only, and each name should have only one meaning. The classical Latin of botanists has been the Latin of Linnaeus, and it will most likely always remain so, because of its definiteness and conciseness. Whatever language is chosen, in the forming of new words we must follow the rules of the language; but we must also remember that by driving the systematizing too far we will only increase the difficulties, and by a too sedulous adherence to preconceived notions we might arrive at results which are not in unison with the true progress of science.

One important point is that in forming new terms for phytogeography we must avoid terms which already, in one form or another, are used in botany. To call an orchard formation dendrium will lead to difficulties, because that name is already used to designate a genus of plants. The same objection can be made to eremia, amathia, lophia, petria, xylia, and scores of other terms proposed by CLEMENTS.

The rule suggested by that author "that a term to be valid must be proposed by a botanist" is incongruous. In hazarding this criticism I must confess that it appears to be a hard rule that forbids any one who has facts to present concerning the vegetation or flora from doing so, provided he is able to express himself correctly, no

matter whether he claims the title of botanist or not. Or is it the coining of names only that should be restricted to botanists? Who is a botanist? Where shall the limit be drawn? Does knowledge of a certain number of plants entitle a man to this privilege? Or is publication of a certain number of pages on some botanical subject a sufficient qualification? If such a rule were accepted and applied, we should have to reject, for instance, the term "ecology," because it was first introduced by ERNST HAECKEL, who never claimed the name of a botanist, although he knew more about the subject than most "botanists."

Enough has been said upon this matter. We should take up a conservative position in this question of nomenclature, but at the same time insist upon the adoption of a code announcing certain principles, the application of which will prevent such a plentiful harvest of confusion as we have now, and assist in bringing about a reform resulting in a nomenclature better adapted to the needs of scientific workers. "Prove all things; hold fast that which is good" is the very essence of such a code.

To summarize the previous discussion:

Clearness and conciseness are the main requisites for a system of terminology.

Each technical term should have only one meaning.

In case of doubtful terms consult the proposer of the name. If the conception it represents is not absolutely clear, the name has no status in nomenclature.

If a term has been commonly used and understood in another sense than the original author proposed, it should be retained, but only in case there can be no doubt as to its interpretation.

If a conception has already received a name and there is no obvious reason to discard that name, an author has no right to propose a new term.

A law of priority is practicable, we think, only so far as the principles laid down in the previous pages of this article will admit.

A name, the conception of which has been materially changed in the course of time, naturally has no standing.

A technical term should be associated in our mind with the idea it represents.

A technical term should be defined clearly, so as to leave no doubt as to its significance. Authors should desist therefore from proposing new terms in mere catalogues.

A new term should be published in some work accessible to scientific workers.

Vernacular names should not be excluded from phytogeographical nomenclature, but they must in every case be definite and give rise to no ambiguity.

An international committee of phytogeographers should be appointed by the Vienna congress, to continue the work on a proposed code of rules.

This committee should consider what kinds of technical terms are needed; how they should be classified, for example with regard to distribution, abundance, elevation, phenological phenomena, etc.

The result of the work of the committee already existing, and of the succeeding one, should be published at an early date, so as to give the public ample time to discuss the various phases of the question, before the following congress assembles.

STANFORD UNIVERSITY, CALIFORNIA.

THE FORESTS OF THE FLATHEAD VALLEY, MONTANA.

CONTRIBUTIONS FROM THE HULL BOTANICAL LABORATORY. LXVII.

HARRY N. WHITFORD.

(WITH MAP AND TWENTY-THREE FIGURES)

[*Continued from p. 122.*]

II. EDAPHIC FORMATIONS IN FLATHEAD VALLEY.

IN the previous pages an attempt was made to show why the west side of the valley contains a prairie formation, and the east side a forest formation, and why the coniferous type of forest prevails rather than a broad-leaved deciduous type. A plot will now be presented in detail to show why in the forest formation there are some areas altogether without trees. In order to reach definite conclusions, a limited area was selected to represent the whole forest area of the valley. This area, comprising about 250 square kilometers, was mapped, and the conditions for forest growth were determined (*map*). The relation of this area to the whole valley is shown in *fig. 3*. It lies at the northeast end of Flathead Lake, and includes a portion of the main valley on the east side of the Flathead River at the head of the lake, the low end of the Mission Range of mountains, and a portion of Swan valley. In this area are found many types of topographic diversity, from Flathead Lake (890 m) to the highest point (about 1372 m) in that part of the Mission Range which is included in the map. No detailed study was made in the higher Swan Range east of the valley, though some conditions of tree growth were noted in these mountains. As shown by the map, five distinct edaphic formations were found: meadow (*hydrophytic*), Engelmann spruce (*meso-hydrophytic*), western larch-Douglas spruce (*mesophytic*), Douglas spruce-bull pine (*meso-xerophytic*), and prairie (*xerophytic*).

THE MEADOW FORMATIONS (HYDROPHYTIC).

As already mentioned, Swan valley was formerly a lake, the present condition being only a stage in its recession. The drainage consists of Swan Lake, Big Fork River, and a number of small

streams; also one large pond known as Ross (Mud) Lake, which, with its outlet Ross Creek and the numerous small inlets, comprise the drainage of the extreme north end of the valley.

The most noteworthy fact about the hydrophytic vegetation is its resemblance to that found in similar edaphic situations in the eastern United States, both types of swamps being found here. Near the head of Ross Lake is a sphagnum meadow, in which *Menyanthes trifoliata*, *Drosera rotundifolia*, *Comarum palustre*, *Eriophorum polystachyon*, and *Betula pumila* are characteristic. At least two other large meadows show this combination. One of these is along Little Bear Creek, and is known as the School Meadow; another is found along Flathead River, and will be discussed in connection with the spruce forest which lies close to it. Ross Lake (*fig. 9*) is a pond which shows very well the zonal distribution of plants, being shallow and with a very muddy bottom. In its center and in streams bordering it are found the following characteristic species: *Nymphaea advena*, *Brasenia purpurea*, four species of Potamogeton, Myriophyllum, and Hippuris. The sedge zone bordering the water of the shallow ponds and streams contains the following species: *Bromus Richardsonii pallida*, *Muhlenbergia racemosa*, *Carex utriculata*, *C. viridula*, *C. hystricina*, *Calamagrostis caespitosa*, *Phalaris arundinacea*, *Juncus Regelii*, *Scirpus lacustris occidentalis*, *Lobelia* sp., *Cicuta maculata*, *Solidago* sp., and *Dodecatheon* sp.

The meadows are usually submerged during the spring and early summer months, when the melting snow of the mountains to the east swells the streams, and brings the water level slightly above the surface. In the latter part of the summer and fall the underground water level is a little below the surface; and it is this condition of submergence and emergence that determines the meadows and excludes trees. Of course some of these meadows are never entirely submerged, but are always wet, with few exceptions being associated with streams. The largest meadows are found near the head of Ross Lake, at its foot on the east side, near the mouth of Wolf Creek, at the foot of Swan Range along Little Bear Creek, and in the large bend of the river just east of Swan River cañon.

The meadows are given brief mention here in connection with this forest study because they are genetically related to the spruce

forests that usually border them. It is obvious that trees do not grow in them because the amount of moisture in the soil is too great. Some of the meadows have been artificially drained, others have been planted to timothy, and one in particular, in the northwestern corner of the area (*map*), has been drained and cultivated for a number of years, so that its former nature was discovered with difficulty. What has been done artificially is being done naturally, but more slowly. The detritus that is washed into the ponds and the vegetation that dies down from year to year are filling up these bodies of water, and are making the meadow condition possible. Again, the streams are cutting their channels deeper, thus lowering the underground water level at their borders, and this changes conditions that favor meadows and introduces those that make the forest possible. It is very probable that many areas now occupied by spruce and other forests were formerly occupied by meadows. Indeed, all stages of development towards this forest condition were noted, and will be discussed under the next head.

THE SPRUCE FORMATIONS (MESO-HYDROPHYTIC).

In many places species of Salix and *Alnus incana* encroach upon the meadows, sometimes forming dense breastworks around the grass areas, so that it is difficult for other trees to get a start. This is the case when the zones of underground water level are sharply and narrowly marked off. Usually, however, when the underground water level is at a fairly uniform distance below the surface for a rather broad area, as it is where the small streams spread out over a level extent of land, the willow-alder breastwork is absent. These situations are favorable for the advance of *Picea Engelmanni* into the meadows. The youngest trees are found on the hummocks in the meadows; nearer its borders are the older ones, though they are still scattered; these grade imperceptibly sometimes into dense forests of spruce, many of the trees reaching huge dimensions. Since this formation is found best developed on situations where the underground water level is a little farther below the surface than it is in the meadows, it may be called the meso-hydrophytic formation.

It must not be supposed that there are no other trees with the spruce; indeed there are only small tracts where pure spruce woods

are found. The most common companion trees are *Populus angustifolia*, *Populus tremuloides*, and *Betula papyrifera*. These species nearly always form a small per cent. of the spruce forests, and in the meso-hydrophytic area along the Flathead River they occupy nearly the entire space. In Swan valley the soil is a mixture of clay and humus; along Flathead River, especially in the delta region, the subsoil is sand, overlaid by a fine alluvial deposit. In the dense woods the undergrowth is scanty, sometimes only one or two species being present, the most common plant associated with the pure spruce growths being *Rhamnus alnifolia*, although *Cornus stolonifera* is often found. In the narrow strip of this forest along the streams nearer the mountain *Echinopanax horridum* and *Veratrum californicum* are present. Since the spruce woods are transitional between the meadow and the mesophytic woods, the undergrowth of these associations is often present. Thus, near the meadow side of the forest, grass plots are frequently present, and on hummocks between anastomosing channels *Lysichiton kamtschatcensis* is frequent. On the other hand, toward the mesophytic side of the forest the elements of the undergrowth of the western larch-Douglas spruce formation are to be found.

An area of spruce is found in connection with a meadow in the northwestern corner of the plot not far from the Flathead River. Here on the border of the prairie formation is an area that has almost identically the same plants as the spruce forest in the Swan valley. Along the east side of this swamp there are numerous springs, some large enough to give rise to small streams, and others hardly noticeable. The source of the water supply is thought to be Echo Lake, which, with a number of smaller ones, lies in the depressions of a moraine that extends beyond the limits of the plot to the northeast. Save a small stream, there is no visible inlet to this lake, and its source of water supply is probably by underground seepage from the mountains that lie northeast. There is also no outlet above ground, and since the drainage is toward the Flathead River it is thought that the springs mentioned are fed by underground seepage from these lakes and ponds. This underground water level, as shown by the wells in the neighborhood, is in places nearly a hundred feet below the surface, and extends underneath the larch-Douglas spruce

and bull pine forests and the prairie to a low ridge near the Flathead River, where it issues in the form of springs, making conditions favorable for an Engelmann spruce formation. Thus a bit of forest is projected, as it were, into the prairie formation. Where the water level comes nearer the surface the meadow already mentioned is associated with the forest.

Another meso-hydrophytic forest in which the spruce is almost entirely wanting needs to be mentioned. Around the head of Flathead Lake, including the delta at the mouth of the river (*figs.* 1 and 4), and extending up the river from its mouth, is a region that is annually submerged.[13] This region is occupied by a dense growth of willows, cottonwoods, birch, aspen, and other trees. On each side of the mouth of the river are long, low peninsulas of sand, the ends of which are entirely barren of vegetation. These are above water only a short time during the growing season, and this fact no doubt prevents plants from getting a start. A short distance back from the end of the delta on a little higher land is *Salix fluviatilis*, in some places so thick as to be almost impenetrable. Underground stems are sent out from this center, and thus new territory is gradually conquered, so that as fast as the delta is built out it is occupied by this pioneer willow, which prepares the way for changes that make it possible for higher forms to exist. When the water is high its contact with the willows causes a deposit of fine silt, so that the delta is gradually built higher and higher, making conditions favorable for the growth of such plants as the red dogwood, other species of willow, narrow-leaved cottonwood, paper birch, aspen, choke cherry, two species of hawthorn, and service berry.

Around the head of the lake there is a low terrace which is also submerged in the spring and early summer months. Instead of *Salix fluviatilis* there is a thicket of other willows; and on the lake side of this there are a few scattered specimens of *S. fluviatilis* and *S. amygdaloides*. On the land side of the willow thicket are the birch,

[13] During the spring and early summer months Flathead Lake and River rise some 4 to 6m, submerging all the surrounding low country. In some instances excessive floods do great damage to the country lying at the head of the lake. Since nearly all streams in the valley have their sources in the mountains to the east, the deforestation of this region would greatly increase these spring floods and greater damage would be the result.

cottonwood, and aspen; and here and there are found small patches or single specimens of the western larch, Engelmann spruce, Douglas spruce, and bull pine. None of these were noticed on the delta proper, and with the exception of the Engelmann spruce they seldom occupy the areas that are often submerged. Of course in the lowest places the meadow type of vegetation prevails, and elements of it are scattered more or less through the area occupied by the trees. As already shown, the lake formerly extended over the valley north of it, and as its waters receded it is very probable that vegetation similar to that found around its shores today occupied similar areas around the shore line of the former lake. Of course as the gradual lowering of the underground water level brings about unfavorable conditions for those plants that exist around the shores, these are replaced by those needing other conditions. On that portion of the shore line that borders the area where the rainfall is insufficient to support trees, the swampy areas will pass through the meadow, the cottonwood-birch-aspen type, to the prairie. However, if the shore line be in a region that has sufficient rainfall to support a forest, the first two stages will be followed by a western larch-Douglas spruce-bull pine stage.

Since the Engelmann spruce is the most prevalent and the most important tree in the formation just described, its sylvicultural habits will be summarized. It has been shown that it does best in soils where the underground water level is not far below the surface, that is, for the plot under consideration, in low-lying lands bordering lakes, ponds, or streams. Thus it occurs not only in Swan valley, but also along the banks of Flathead River, where it is somewhat sparingly mixed with cottonwood-birch-aspen groups. It is the first tree to advance into the meadows. However, the Engelmann spruce is not confined to the more or less swampy region, for it is found scattered through the mesophytic areas in Swan valley. In the stands that lie adjacent to the spruce forests it is almost always present, and in some places it extends well out into the drier parts of the western larch-Douglas spruce formation, being found beyond the limits of the silver pine and lowland fir, and having a wider life range than either of these two species. It was often observed in the bull pine-Douglas spruce association where depressions in the topog-

raphy brought the surface of the soil near the underground water level, and along streams. However, trees in these situations seldom reach large dimensions.

The Engelmann spruce can tolerate shade fairly well; in this respect it is different from western larch and Douglas spruce and is classed with silver pine and lowland fir. The fact that it can endure shade probably accounts for the presence of its seedlings in the forests that occupy the drier areas in the plot, for the forest canopy in these situations brings about a local climate that makes it possible for trees to exist that could not otherwise do so. The Engelmann spruce has the power of germinating in the open if there is sufficient soil moisture, and like the other shade-enduring species it does better in these situations than in the shade.

It will be seen from the foregoing that outside the semi-hydrophytic conditions Engelmann spruce does not flourish in the plot under discussion, being confined to the level stretches of land bordering on the meadows and open bodies of water. There is little doubt that as the waters of the former Swan Lake withdrew, meadows first occupied these areas and then were replaced by spruce stands. Just as the meadow conditions may be considered the first stage in the development toward the climax forest of the region, so the spruce forest may be considered the second stage. As the channel of Swan River is cut deeper the water level of the valley will be lowered, thus bringing about a condition favorable to the development of other types of forest which will replace the spruce association.

In the above account the distribution of the Engelmann spruce is discussed only in the area mapped. In the mountains bordering the area on the east it shows a wide altitudinal range, but is always associated with good moisture conditions, for it is found best developed in the damp cañons and on damp slopes where it is invariably associated with *Abies lasiocarpa*. In the high basins it does not do so well as the fir, but in the lower valleys it flourishes where the alpine fir does not.

THE WESTERN LARCH-DOUGLAS SPRUCE FORMATIONS (MESOPHYTIC).

In the discussion of the Engelmann spruce formation it was shown that on its borders and on the dry hummocks in stands of this tree other trees obtained a foothold. Just as there is a gradation from

the meadows into the meso-hydrophytic forest in which the Engelmann spruce predominates, so there is a similar change from these into a forest in which the western larch and Douglas spruce are the principal trees. Again, this difference is due to a change in the underground water level; in the meadows it is near the surface; in the Engelmann spruce stands it is slightly below the surface; and in the western larch-Douglas spruce combinations it is still farther below. Indeed, in this association the water level is so far below the surface in places that the roots of the trees do not reach it, but rather depend on the water in the surface layers that comes from the rains or by capillarity from the underground water level. Since there is a medium condition of water in the soil, the forests occupying these areas are known as the mesophytic formations (*fig. 8*). Other trees found with *Larix occidentalis* and *Pseudotsuga taxifolia* are *Pinus Murrayana*, *Abies grandis*, *Pinus monticola*, *Picea Engelmanni*, *Thuja plicata*, and occasionally *Abies lasiocarpa*, *Pinus ponderosa*, and *Tsuga heterophylla;* also certain deciduous trees.

Associated closely with the spruce and almost invariably surrounding stands of it, except where the lodgepole pine is present, is found a forest in which the silver pine and lowland fir are at their best. Thus on the west side of the bay-like area of meso-hydrophytic forest west of Ross Lake, the spruce is gradually replaced by a magnificent growth of lowland fir, silver pine, western larch, and Douglas spruce. The lodgepole pine occupies a good deal of the spruce stands that would otherwise have developed into a forest like that just mentioned, were it not for the influence of fires. In various other areas are found forests in which silver pine and lowland fir form a more or less conspicuous element, especially in the area near the mouth of Meadow Creek. They are never unaccompanied by other species and seldom become the dominant trees, probably because the climate is not so congenial to them here as to some of the other dominant species.

The silver pine closely resembles its relative the eastern white pine. As already stated, in Flathead valley it does its best in the conditions surrounding the spruce stands, or where the water level is not far below the surface. However, it spreads over nearly all the mesophytic region in Swan River valley and ascends the east slope

of the Mission Mountains in moist situations. In the swampy soils silver pine has a shallow root system and is easily blown over by winds, many large trees being observed lying prostrate with nearly the entire root system exposed. Where the soil has sufficient moisture, this tree can germinate in the open with no shade whatever, but it can pass the seedling stage in rather shaded conditions. The only two trees that have a shade too dense for it are the giant arborvitae and the western hemlock. While it can exist in the shade around the drier edges of the mesophytic forest, it fails utterly to maintain a stand in the mature growth of these areas, and except in extremely favored places the silver pine cannot be considered a successful tree for the region under consideration. It succumbs easily to fires, many instances being noted where fires had swept through the forests destroying the silver pine, while such trees as western larch and Douglas spruce were only slightly damaged.

The distribution of lowland fir is very much like that of silver pine, both reaching their climax growth in about the same situations. Where the water level is rather far from the surface it is more successful than silver pine in the low altitudes; but its altitudinal range is less than that of the latter. It is able to develop in open places, in soil so dry that silver pine is excluded. Where the moisture was sufficient it was not an uncommon thing to find stands of small (3 to 5^{m} high) trees so dense that absolutely all vegetation was lacking beneath them. It is more tolerant of the shade than is silver pine, and because it can grow in drier soils it extends as undergrowth into the borders of the meso-xerophytic regions, where silver pine is seldom if ever found. Like silver pine and Engelmann spruce, the range of this tree is extended because of the protection of the forest canopy, but this is not the region of its best development. The largest trees seen were less than a meter in diameter and not more than 38^{m} in height. SARGENT reports that it attains its best development along the Pacific coast in Washington, Oregon, and northern California, where it is frequently 75–90^{m} in height.

By far the most successful tree in Flathead valley is western larch. It is a tree that closely resembles its eastern relative (*Larix laricina*) in general appearance, although its habits are decidedly different (*fig. 11*). As already shown, it is one of the first trees to gain a foot-

FIG. 11.—View of interior of a western larch-Douglas spruce forest near Big Fork, Montana; the undergrowth consists of *Acer glabrum*, *Philadelphus Lewisii*, *Holodiscus ariaefolia*, etc.—From photograph by MCCALLUM.

hold in the spruce association, where it is found on the ridges and hillocks, and it forms an important element in the neighboring forests. There are extensive areas in Swan valley where this is decidedly the predominating species, and on the west slope of the Mission Range in some places there are almost pure stands. It extends out into the prairie regions along the river courses and on protected slopes. It does not grow in as dry soils as Douglas spruce and bull pine, and hence is more restricted in its distribution in regions where the rainfall is slight. The young trees, unlike those of silver pine and lowland fir, cannot endure shade. In no instance was a seedling observed growing in the shade of a forest. Other things being equal, it does best in broad open places, although it can do fairly well in slight openings where the sunlight enters at least during the middle of the day. The western larch then does not tolerate shade and cannot reproduce itself unless an opening be made first in the forest. This may be done in the mature primeval forest by the dropping out of old trees, but more frequently accidents such as fires and winds bring about open places suitable for its reproduction, provided of course seed-bearing trees are left to stock the soil with seeds. In contrast with silver pine and lowland fir, it may be called a fire-resisting tree. Its thick bark enables it to withstand fires that would kill silver pine and lowland fir, old trees often being found still living in the midst of burned areas. Sometimes isolated trees stand towering over the young lodgepole pine growth that has come in after fires (*fig. 12*), and the only young trees competing with lodgepole pines are western larch.

Observations on the rooting habits of trees are in any case difficult to obtain, unless windfalls are frequent. Many trees of western larch were found standing in windfalls where silver pine, lowland fir, and Engelmann spruce had been blown over. From this one would judge that its roots penetrate much deeper than the roots of these trees; indeed this may be one of the reasons why western larch is able to exist in drier areas than can some other trees, for a deep root system will enable it to reach nearer to the underground water level or at least below the superficial dry surface layers where a tree with shallow roots could not get sufficient moisture.

Since Douglas spruce is a successful tree in the regions bordering

on the prairie, a discussion of its sylvicultural habits will be deferred until the meso-xerophytic forest is described. It is almost invariably

FIG. 12.—Three generations of forests in a "burn" near Ross Lake; first generation represented by isolated old specimens of western larch; second generation consists of a forest of lodgepole pines mixed with a few individuals of western larch; in the foreground is the third generation, which consists almost entirely of young trees of lodgepole pines.—From photograph by PRAEGER.

a companion of western larch in the mesophytic area, hence the name western larch-Douglas spruce association.

The giant arborvitae is another tree that needs brief mention here. In the plot under discussion, along the base of the Swan Range there are three isolated places where the arborvitae was noted. It is usually found in moist places and probably ought to be considered as a meso-hydrophytic rather than a mesophytic tree (*fig. 13*). West of the Cascade Mountains, where it reaches its greatest development, it is distinctly a tree of the moister regions.

Another tree found in Swan valley is alpine fir, mentioned before as associated with Engelmann spruce in the moist cañons of the mountains. From here it spreads to the subalpine regions where it occupies a prominent place in the basins where snow lies all the year. In places it also finds its way into the lower altitudes in rather moist situations, as in Swan valley. The birch maintains a place throughout the mesophytic area; especially is it frequent in the moister situations and mixed with the lodgepole forests.

The soil in the mesophytic area is variable in nature, the character of the vegetation changing to a certain extent with the variations. It is probably not the chemical composition that determines the kind of forest, but rather the physical composition, the capacity of the soil for holding water being the controlling factor. If the underground water level is not far below the surface, it makes little difference whether the soil is sand, clay, or gravel, so long as there is sufficient humus to furnish the needed nitrates. However, back from the low-lying lands, where the water level is too far below the surface to be reached by the roots of the trees, the physical character of the soil plays an important rôle. As a rule the soil of the valley is made up of clay, probably derived from the decay of the dolomitic shale, the principal rock of the surrounding mountains. This has been washed in and deposited in the bed of the former more extended Swan Lake, and is mixed more or less with silt. Humus has accumulated in places, and this is more abundant where fires have not been so prevalent; for not only do fires destroy the humus, but in the open places left after the destruction of the forest it dries out rapidly. In contrast with the rich beech and maple woods of the eastern United States, the humus content of the soil is considerably less in these coniferous forests. This is of course due to the fact that the needle leaf of the conifers is not so good a humus producer as the

FIG. 13.—Giant arborvitae forest in an inlet of Sinyalcamin Lake, in a part of the Mission Mountains not in the plot mapped; the young trees under the old stand are all arborvitae, as no other species can exist in so dense a shade.—From photograph by HAMILTON.

broad leaves of the maple, beech, and other deciduous trees. In places, however, considerable quantities of humus are present, especially where the trunks of fallen trees have been allowed to decay and have not been destroyed by fire. A very good indication of a soil rich in humus is the number of species of fungi and mycotrophic seed plants found in it; *Monotropa uniflora*, *Pterospora Andromeda*, and *Corallorhiza multiflora* being scattered rather thickly throughout the forest. However, one misses the rich array of fleshy fungi found so abundantly in the leaf mold of the deciduous forests. Except in those places where arborvitae, hemlock, and lowland fir are prominent, the shade is not very dense; and under the rather thin canopy of the other conifers there is enough light to permit the development of a number of semi-shade species.

A woody plant that gives a decided tone to the undergrowth throughout the mesophytic area and to some extent in the meso-xerophytic area is the dwarf maple (*Acer glabrum*), the only representative of the maples found in Flathead valley. It can hardly be called a tree, for it seldom becomes more than 3^m in height. Other characteristic shrubby plants are *Salix* sp., *Philadelphus Lewisii*, *Holodiscus ariaefolia*, *Amelanchier alnifolia*, and *Symphoricarpos* sp. In some places, usually more mesophytic, *Menziesia urceolaris* and *Taxus brevifolia* are found. Some of the forms, like snowberry, service berry, and mock orange, become more frequent as the forest becomes more open. Among the prominent more lowly forms were noted the following: *Berberis aquifolium*, *Aralia nudicaulis*, *Cornus canadensis*, *Chimaphila umbellata*, *Pyrola rotundifolia*, *Linnaea borealis*, *Rubus parviflorus*, *Clintonia uniflora*, *Adenocaulon bicolor*, *Tiarella unifoliata*, *Lycopodium* sp., and *Disporum* sp.

At the south end of Swan Lake, on the west side of Big Fork River, is an area with a soil decidedly pebbly, and probably of glacial origin (*map*), its inability to hold water being indicated by the character of the forest it supports. The Douglas spruce is about the only mesophytic tree found here, and in places there are groves of bull pine. On the east side of the river, so persistent is the absence of other species than Douglas spruce and bull pine, that the area was mapped as meso-xerophytic forest rather than mesophytic. It is rather open, and the vegetation in it becomes somewhat prairie-like;

indeed everywhere that the mesophytic forest grades into the Douglas spruce-bull pine combination the forest floor has prairie plants rather than forest forms.

It has been shown that the western larch-Douglas spruce association is found in those areas where the amount of water in the soil is less than in the areas that support the spruce formation. Again, attention must be called to the fact that in the former extension of the lake many parts of the valley now having mesophytic forest were moist enough to support spruce forests, and as the water of the lake receded the amount of water in the soil became less and less until the encroaching mesophytic forests crowded out the spruce forests. As there is a relation in origin, therefore, between the meadows and the spruce forests, so there is also a genetic relation between the spruce forests and the western larch-Douglas spruce forests. In places where the hills end precipitously near the lake shore, as on the west side of Swan Lake for instance (*map*), this relation is not so apparent, for the mesophytic forests reach in many cases to the water's edge. Yet even here narrow, flat areas at the foot of the mountains on the borders of the lake have small meadows with scattered Engelmann spruce and cottonwood in them. These will give way, of course, to the encroaching mesophytic element when the waters of the lake have further withdrawn.

In conclusion it may be pointed out that the climax forest of the plot under consideration is the western larch-Douglas spruce formation. This association occupies a greater portion of the comparatively level stretches of Swan River valley (*fig. 8*). It also is found on the protected slopes and foothills of the low Swan Range. No attempt was made to determine its range outside of the region mapped. The trees that are characteristic of this forest are western larch, Douglas spruce, silver pine, lowland fir, Engelmann spruce, and lodgepole pine.

THE DOUGLAS SPRUCE-BULL PINE (MESO-XEROPHYTIC) AND THE PRAIRIE (XEROPHYTIC) FORMATIONS.

Since the Douglas spruce-bull pine associations and the prairie are more or less connected, they will be treated together. A reference to the map will show that a rectangular plot of ground known

as Nigger Prairie lies just north of Swan Hill, at present used for farming purposes. It is bordered on the south, east, and west by narrow strips of pure bull pine forests, and on the north a forest of

FIG. 14.—View of bull pine forest south of Echo Lake; in the center is a large bull pine, the younger growth around consists of bull pine with some Douglas spruce. —From photograph by PRAEGER.

the same species extends to Echo Lake (*fig. 14*). This bull pine stand is surrounded on all sides by a mesophytic forest in which western larch and Douglas spruce almost entirely replace bull pine.

The question arises, what is the cause of this difference in the character of the vegetation in so limited an area? So far as could be ascertained, trees have been absent from Nigger Prairie for at least twenty years, and it is very probable that it has never been forested.

The character of the soil in both the prairie and the bull pine zone surrounding it is decidedly different from that of the country immediately adjacent. That to the south and west is a residual clay from the dolomite shale of Swan Hill; that to the east is a clay rich in humus; and that to the northwest, north, and northeast is a pebbly clay of glacial origin. On the other hand, the soil of the entire prairie and bull pine region is composed of sand mixed in places with a considerable amount of humus. The limits of this sandy area extend a little beyond the limits of the bull pine forest. It seems very probable that the absence of any other trees than bull pine is due chiefly to the physical character of the soil. It must be remembered that the climate of the area under discussion is such as barely to favor a forest, and a slight difference in the amount of water which the soil can hold may lead to the exclusion of certain trees, and in places of all trees. Since a sandy soil lets water drain through it readily, it is very likely that this area is too dry to support a mesophytic forest. As shown by wells, the underground water level in Nigger Prairie is some distance below the surface, so that those trees which have shallow root systems would not be so likely to succeed as those whose root systems are extensive and deep. The bull pine is one of the latter kind, and it is very likely that this is one reason why it has the habit of growing in drier situations than some of the other trees.

If the surface layers of a sandy soil can be made to retain water, the objectionable feature of such a soil will be partly overcome, and this can be brought about by an accumulation of humus. Lower forms of vegetation, even grass, by their decay will add to the humus content of the soil. In very dry countries this accretion would be exceedingly slow, for the oxidation of the organic débris would be great; but even in dry situations by the accumulation of a slight amount of humus the water-holding capacity of the soil might be increased sufficiently to tide a few trees over the driest months of the year. Trees once established in this way would help accumulate

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humus more rapidly, for by fall of the dead limbs and leaves more organic material would be added than from the decay of lower forms of vegetation. The shade of the trees thus established would check the rapid oxidation of the organic material that takes place in the open. The ultimate effect would be the establishment of a forest in a place that was formerly occupied by a prairie. It is very probable that the whole yellow pine area just described was at one time occupied by a prairie vegetation. There is evidence that the present prairie island in this forest would become covered with forest trees if not interfered with by man, for along the roadside groups of young growth of bull pine seedlings are not uncommon. All around the border of the prairie young trees are present, and even in a timothy field there were noted seedlings that had escaped being cut by the mowing machine. Before the prairie island was settled it is very probable that surface fires swept it occasionally and thus checked the conquering of the prairie by the forest. Another prairie area similar to the one just described lies directly west of Echo Lake (*map*). Again, west of Nigger Prairie, just across the low range of Mission Mountains, is another "sand pocket" that has a prairie vegetation. These however border on the prairie climate.

The question arises whether the presence of bull pine will in any way change the conditions sufficiently to make them capable of supporting other species of trees. It was shown that the humus content of the soil increases more rapidly when trees are present than when they are absent. With the gradual increment of organic decay, it is very possible that the water-holding capacity of the soil may be increased to such an extent that it will be rendered capable of supporting other species of trees.

A bull pine seedling does not tolerate shade; the young tree must have broad open places where the sun strikes the soil a greater portion of the day. An opening in the forest made by the removal of one or two trees does not allow sufficient light and heat to enter; thus young stands are excluded from anything like a tolerably thick growth of these trees. This is not the case with western larch and Douglas spruce; it has been shown that the former does not tolerate shade, but grows in slight openings in the forest; the latter is very similar in this respect to western larch. If humus has accumulated

FIG. 15.—View of an arm of Echo Lake, showing submerged cabin and timber land; a few years ago this was dry land; the trees in the foreground are western larch and Douglas spruce.

so as to give the soil a sufficient water-holding capacity, open places in the bull pine forest may permit seedlings of both the species named to thrive. Numerous instances of this were noted in the bull pine forest under consideration. In places where bull pine had been removed there were clumps of young trees of Douglas spruce and western larch. If the place is sufficiently open, bull pine seedlings are found with the others. It will be seen readily that such a condition will lead to a gradual replacement of the bull pine forest by the Douglas spruce-western larch combination. There is some evidence that such a succession has already taken place, for all around the borders of the "sandy pockets" western larch and Douglas spruce are more numerous in places than bull pine. There is also reason to believe that in the pebbly clay morainic soil around Echo Lake, especially to the south and northwest, a more or less pure bull pine stand preceded the present stand consisting of a mixture of the three species. The bull pines are found in groups, or solitary full-grown specimens overtop the younger growths of the next generation of Douglas spruce and western larch, these isolated specimens doubtless representing all that is left of the former pure bull pine stand. Of course this succession has been a gradual one, occupying many generations, the more successful trees elbowing their way, as it were, among the less successful until the spread of the latter is limited by their incapacity to adapt themselves to the new environment. All stages in this succession are present today in the forest under discussion, and it was the study of these stages that led to the conclusion that has been advanced.

Out towards Flathead River the zone between the prairie and the forest contains a few scattered specimens of bull pine; next to this there is a more dense stand of this species with a few scattered trees of Douglas spruce; back farther still from the prairie is a zone in which bull pine is less and Douglas spruce more frequent; and finally another condition is found in which western larch joins these two species, bull pine being the least conspicuous element of the three. Such an arrangement is approximated just west of Echo Lake. This region is decidedly morainic in its character, and where depressions approach the underground water level western larch becomes more numerous, and in places near Echo Lake the surface

of these depressions comes near enough to the water level to permit the growth of scattered Engelmann spruce. This level of underground water varies, and this change is shown in the rise of the lake itself and the ponds around it (*fig. 15*).

Mention has already been made of the western larch-Douglas spruce combinations on the protected slopes of the Mission Moun-

FIG. 16.—View on the top of the Mission Mountains showing area on which the Douglas spruce-bull pine forest has been destroyed by fire; the outcrop of dolomitic shale has been scoured smooth by the action of glacial ice; Ceanothus bushes on the right, lichens of various sorts on the rocks, and prairie grasses where the soil is sufficiently deep.—From photograph by PRAEGER.

tains. Toward the top of this slope western larch becomes less and Douglas spruce more prominent; in places the latter is mixed with lodgepole pine. On the west side of the range Douglas spruce and bull pine are the principal species; hence this area has been mapped as meso-xerophytic, although western larch is present in some situations.

The altitude of the Mission Range within the limits of the plot is nowhere more than 1372^{m} above the level of the surrounding country. The core of the mountains is composed of a dolomite shale, which outcrops in many places. Especially is the rock near the surface on the steep northwest fault face and where the soil has been removed by the action of glaciers (*fig. 16*). South of the river the forest on the western slope has been partially destroyed by fire (*figs. 16* and *17*), but enough of the original stand remains to give a clue to the conditions of the whole slope. A discussion of the burned area will be taken up in another connection.

Wherever the rock outcrops there is little or no vegetation (*fig. 16*), due to the fact that there is no soil; the pioneer plants on the rocks here, as elsewhere, are the lichens. The crustaceous lichens appear where there is absolutely no disintegrated rock; sometimes associated with these are the foliaceous forms, but these are more common where a little soil has accumulated; with these are found mosses adapted to the dry conditions. After more soil has accumulated, conditions are favorable for plants that require more moisture; among these are the fruitcose lichens, *Cladonia rangiferina sylvatica* being a good example. Associated with these lichens are *Selaginella densa, Sedum Douglasii, Heuchera parvifolia*, the last being usually found rooted in cracks. These plants prepare the way by their decay for the higher forms that can get a foothold as soon as sufficient soil is present. The inorganic material made by the disintegration of the rocks is blown or washed in from the surrounding region and reinforces the organic accretion. In the meantime the rock crevices have been filling up with soil, thus furnishing favorable places for shrubs like *Prunus demissa, Symphoricarpos* sp., *Amelanchier alnifolia*, and *Juniperus sibirica;* and *Campanula rotundifolia, Arctostaphylos Uva-ursi*, and grasses are early pioneers in these places. If the outcrop is near a large body of water like Flathead Lake, *Juniperus scopulorum* is one of the first trees. This tree is found distributed around the shores of the lake and along water courses in the prairie region in the valley at the foot of the lake, and with it are found Douglas spruce and bull pine. These of course gain a foothold by sending their roots into the rock crevices and may play an important rôle in the weathering processes by prying the rocks

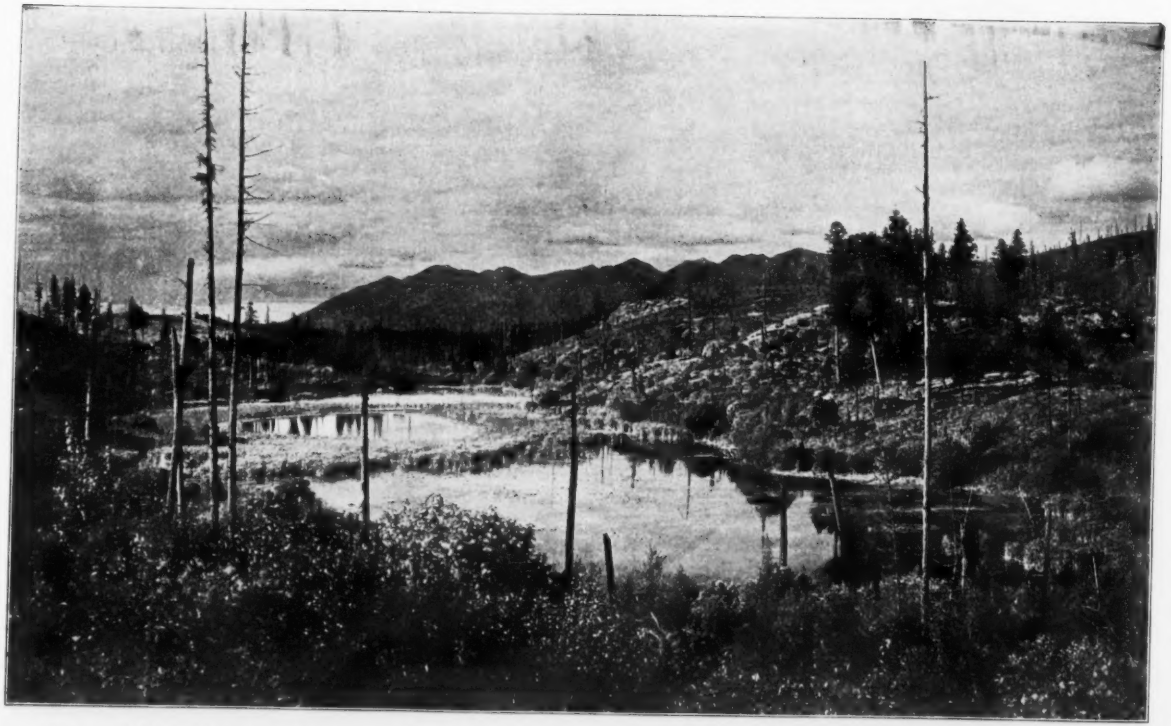

FIG. 17.—View of burned region on west slope of Mission Mountains; Daphnia pond nearly filled with hydrophytic vegetation; the forests of larch, Douglas spruce and bull pine almost entirely destroyed; the bushy growth that becomes vigorous after the forests have been destroyed is Ceanothus, Amelanchier, Salix, etc.—From photograph by ELROD.

apart in the growth of their roots. However, on the rocks there is never more than a scattered growth of trees. Where the soil is less shallow, more trees are present and a more closed stand is developed. In the ravines and other situations where a deep soil has accumulated, a heavy growth often occurs; especially is this true in the protected ravines and on the sheltered slopes. Along the front of Flathead Lake there is a series of ridges which has an open growth of Douglas spruce and bull pine on the side facing the lake; and protected from winds, the slopes on the east side of these ridges and the valley between them and the higher ridges to the east have in addition western larch, which in places is the dominant tree. Again, where the surface of this valley is not far above water level, Engelmann spruce and its associates are found, though these places are infrequent. In many protected areas on the west side of the Mission Range western larch is present, though as contrasted with the eastern slope the exposed western face of the mountains is not so favorable a habitat for the mesophytic trees.

The temperature conditions on top of these mountains and at the foot are not known. No doubt the climate is considerably cooler at an altitude of 1372^{m}, the highest point of the range in the plot, than it is at 890^{m}, the level of the lake. However, this difference is not enough to exclude the lowland species and introduce those found on the higher Swan Mountains to the east. The presence of a large body of water like Flathead Lake no doubt influences the temperature conditions along its shores, for early fall frosts are less frequent here than at a short distance inland. Whether or not this affects the forest growth is not known.

[*To be concluded.*]

BRIEFER ARTICLES.

TERMINOLOGY OF THE SPORE-STRUCTURES IN THE UREDINALES.[1]

SOME time ago I began to study groups of species among the rusts in a more methodical way than usually pursued, and as part of the method undertook to prepare uniform descriptions in which like parts of each structure should receive the same kind of treatment in every case. I soon met with an obstacle that had not been anticipated. The terminology in use was found to be clumsy, ambiguous, poorly correlated, and quite inadequate to show homologies properly.

I will illustrate a few of the difficulties which confronted me. When an aecidium is mentioned, there is a tolerably clear conception of a cup-like structure filled with spores; but when one reaches the next stage of the rust, what is the meaning conveyed by the word uredo? I think it is most generally employed as a collective term, referring to the second stage of the rust. We can properly say that the uredo occurs on leaves of a certain host, but if we wish to specify a single uredinial structure corresponding to an aecidium, it is necessary to say uredosorus; and yet it is not permissible to say aecidiosorus. Passing to the third stage of the rust there appears to be neither a specific nor a collective name with which to designate it. The nearest approach to a specific term analogous to aecidium is teleutosorus, and to a collective term analogous to uredo is teleutostage. We can say properly that aecidia appeared on a leaf, after a time they were followed by the uredo, and finally the teleutospore stage was developed; in which statement we have used three different methods to express the same idea relative to similar spore-structures.

Taking up the first stage again, there appears to be nothing inappropriate in calling the single spore-structure an aecidium so long as we have in mind the first stage of species belonging to the genus Puccinia or Uromyces; but in the genus Phragmidium there is no peridium present, and in Gymnoconia not only is the peridium absent but the spore-layer is extended and indefinite, and the term aecidium now seems far less applicable. For such cases it is customary to call the structure a caeoma, instead of an

[1] Read before the American Mycological Society at Philadelphia, December 30, 1904.

aecidium, adopting the generic name established by TULASNE in 1854, who applied it to forms without a peridium and having the spores in chains. But in the genus Coleosporium it is the uredostage, and not the aecidium, that possesses the caeoma structure. Moreover, care must be exercised not to confound TULASNE'S caeoma with LINK'S caeoma. For in 1809 LINK established a genus Caeoma to cover pulverulent forms of rust, whether the spores were borne singly or in chains, which was extensively used by mycologists of the time and subsequently, including SCHWEINITZ and others in America. But the terminology for the first stage of a rust is not yet exhausted. If the stage occurs on a pomaceous host, one is usually safe in calling it a roestelia; and if on a coniferous host, it is usually styled a peridermium. But there are plenty of instances among the less common forms of rust where none of these many terms seems accurate.

Turning to the second stage of rusts fortunately we do not find so many terms in use. The spores are usually borne singly on pedicels, and are generally called uredospores, or when borne in chains they are caeomospores. If the sorus happens to be surrounded or filled with prominent paraphyses, the spores become epiteospores, although this term is derived from a generic name first applied to an aecidial form. It has seemed to me providential that when the uredosorus is surrounded by a peridium, as in species of Pucciniastrum and Cronartium, we are not required to have some other sort of spore, and are permitted to say simply uredospore.

I have only cursorily mentioned some of the most obtrusive difficulties encountered, when I undertook seriously to record comparative studies of the rusts. I should probably never have publicly rebelled against this confusion of superfluous and yet inadequate terms, had I not after a time become interested in generic nomenclature. So long as there seemed to be no impropriety in allowing a generic name to wear out and be cast aside, or to be subjected to the menial duty of designating a form of spore, it seemed unreasonable to make complaint. But when the conviction became firmly established that a uredineous genus was entitled to as much dignity of position as the genus in any other group of plants; and when it became evident, moreover, that in the application of the rule of priority some of these degraded genera might suddenly assume the place usurped by long accepted names, as for instance, KUNTZE would have us believe that Roestelia should take the place of Gymnosporangium, then I thought it time to look into the possibility of emending, changing, or in some way improving the terminology of the spore-forms. Pursuing my generic studies further, it appeared little short of absurd that one of the earliest genera, and until recently one of the largest, which has embodied the most

prominent idea of the order both in the scientific mind and in the popular mind, and which supplied the accepted name by which the order is now known, I mean the genus Uredo, should be wholly discredited and abandoned, and according to many able mycologists even lose its rights in synonymy. When I came to believe that the names Uredo, Aecidium, Roestelia, Peridermium, Epitea, and Caeoma were entitled to rank as acceptable genera, provided they were not antedated, it became certain that these names should no longer be made to do duty as spore-names.

For the several reasons which I have now partially illustrated, I was impelled to seek for more serviceable, accurate, and concise names for uredineal spore-structures. More than a year ago I presented the first installment of my problem to Dr. FREDERIC E. CLEMENTS, of the University of Nebraska, and it is to his continued and hearty cooperation and suggestion that I am able to present at this time a well considered series of terms to designate the several spore-structures of the Uredinales. I think the claim can be justly made that these new terms, all constructed by Dr. CLEMENTS, will do away with ambiguity, have a definite and easily recognized application, permit of uniformity of statement for the several spore-stages, and promote clear conceptions of homologies.

The terms I have to propose apply to the sorus. By sorus is meant the structure which arises from a single, fertile hyphal mass, or hymenium, either with or without a peridium, now usually called spermogonium, aecidium, uredosorus, teleutosorus, or kindred names. A compound sorus is produced by a number of sori standing close together, separated and surrounded by modified hyphae, which form a stroma, erroneously termed paraphyses, *e. g.*, the teleutosori in *Puccinia rubigovera* and *Puccinia Virgaureae*. The stroma is not considered a part of the sorus, but an adjunct structure. A simple sorus is surrounded by the tissues of the host, or by unmodified mycelium, and includes the peridium, and all true paraphyses, whether peripheral or discal.

The new terms consist of four words, with their derivatives, one for each of the four stages of uredineal fungi. For the sorus of the initial stage, usually designated by a cipher, and called spermogonium, pycnidium, etc., I propose *pycnium* (*πυκνίον*); derivatives *pycnial*, *pycniospores*, etc. For the sorus of the first spore-stage, usually designated by the Roman numeral I, and called aecidium, roestelia, peridermium, etc., I propose *aecium* (*αἰκίον*); derivatives *aecial*, *aeciospore*, etc. For the sorus of the second spore-stage, usually designated by the Roman numeral II, and called uredosorus, etc., I propose *uredinium* (uredo); derivatives *uredinial*, *urediniospore* or if preferred *uredospore*, etc. For the sorus of

the third spore-stage, usually designated by the Roman numeral III, and called teleutosorus, I propose *telium* (τέλίον); derivatives *telial*, *teliospore*, etc.

These four words and their derivatives have sufficient resemblance to corresponding terms now in use to suggest their meaning, and thus facilitate their introduction; and yet they are all new words and are now brought before the scientific public for the first time. All the words are shorter than the corresponding ones now in use, except urediniospore, which is longer by three letters than uredospore, but no more difficult to pronounce, and for this the word at present in use, uredospore, may well be retained. No permissible shortening of the stem of this term has seemed feasible, and yet have the uniformity and classicism of the series preserved.

I may be permitted to illustrate the use of these words by a similar sentence to that employed at the beginning of my paper. In the case of wheat rust, aecia appear on the leaves of the barberry in spring, preceded by pycnia; the aeciospores give rise in due course of time to uredinia on the wheat plant, followed by telia. A similar statement could be made for a Coleosporium, Phragmidium, or any other rust. One might explain the difference between the telial stage and the uredinial, or discuss the status of pycniospores as compared with teliospores or other sorts, or he might point out that the sorus of a uredinium has the same essential structure whether without peridium and stylosporic, as in Puccinia; with peridium and stylosporic, as in Pucciniastrum, or without peridium and the spores in chains, as in Coleosporium; and so on.

Finally, the acceptance of these terms would require that the following terminology for the receptacles, spores, etc., of the rusts should be substituted for the series recently given by SACCARDO in his *Nomenclatura mycologica*, viz., sorus, pycnium, aecium, uredinium, telium, peridium, stroma. Mesospore, amphispore, stylospore, etc., are special descriptive terms, which may be extended indefinitely as need arises, but do not form part of the general category. Caeomospore, epiteospore, aecidiospore, and other terms compounded from generic names should be wholly discontinued. Peridium is to be preferred to pseudoperidium, in accord with the usage of DECANDOLLE, LÉVEILLÉ, and many recent mycologists. Brevity, directness, and accuracy are excellent qualities to keep in mind when deciding upon terminology.—J. C. ARTHUR.

PURDUE UNIVERSITY,
Lafayette, Ind.

CURRENT LITERATURE.

BOOK REVIEWS.

Plant chemistry.

MANY BOOKS have been written on physiological chemistry, but for the most part these deal specifically with substances which are of chief interest to the animal physiologist; and generally they undertake to treat the characteristics and modes of reaction of a very great number of individual substances more or less independently of their biological relations. The book before us has a definite aim. CZAPEK[1] has sought to bring together a collection of facts which should be at once complete and critically verified, in order that these may form a point of departure for further researches. The field of plant chemistry has been so neglected, comparatively, that scarcely more than ordinary industry suffices to make notable advances in knowledge.

Such a book, of course, will be of value to many other than plant physiologists. The service which CZAPEK has done is likely, therefore, to have wide and hearty appreciation. The book is not intended for the beginner in biochemics, but assumes a general knowledge of both botany and chemistry, being intended specifically as a reference book and repertory of literature for the help of investigators of special problems.

The book opens with a brief historical introduction, in which the author touches lightly yet clearly the service of chemists of the Middle Ages and of those who labored after the transformation which chemistry underwent through the genius of LAVOISIER. The work then is divided into two parts, general and special. The general part occupies something over ninety pages, and is of decided interest to the reader who is familiar enough with modern chemistry to appreciate this brief and illuminating discussion. The author considers the nature of the protoplasm and the substances of which it is composed; the properties of colloids, the structure of the protoplasm and its biochemical significance; the conditions and rate of chemical reactions, and especially the ionic reactions in living cells. The last three sections, in which are discussed catalysis and catalysers, the general chemistry of enzymes, and the cytotoxines and similar compounds, deserve particular notice.

The special part of the present volume is confined to a consideration of fats, lecithines, phytosterines, waxes, and the carbohydrates. To the last named much the larger part of the volume is devoted. Each of these classes of materials is discussed in its relations to various groups of plants, or to the various plant parts in which it is found. In this feature we have the most radical difference between

[1] CZAPEK, F., Biochemie der Pflanzen. Bd. I. Imp. 8vo. pp. xv+584. Jena: Gustav Fischer. 1904. M 14.

this book and most of the previous works on physiological chemistry, and even of the few that have been written with special reference to plant chemics.

A second volume is already in press and may be expected ere long. We suppose that a detailed treatment of the proteids will occupy the greater part of it. It will be accompanied by full indexes.—C. R. B.

Plant organization.

IN 1899 we noticed the first part of a work by BERTHOLD on plant organization,[2] of which the first half of the second part, promised "very soon," has recently appeared.[3] The author announced his intention of discussing in this second part in a comprehensive way the investigations made by himself and others. This promise rests in large part unfulfilled.

We find an "introduction" of twenty-one pages (which seems queerly out of place in the middle of a book) setting forth the aims and methods of this "Physiologie der pflanzlichen Gestaltung." BERTHOLD assumes that the protoplast is a mechanism, made of different individual parts, even though they cannot be distinguished, each having its particular function. This assumption is developed at length. Of course, therefore, he objects to the idea of adaptation in connection with anatomy, especially as developed by HABERLANDT. He rejects the ideas of growth enzymes and of *Anlagen* as indicating useful directions for research, and minimizes the value of studies on regeneration in the problem of plant organization.

In the special part (pp. 22–257) BERTHOLD discusses in four chapters the morphology of the typical (*sic*) shoot, the pith, the primary cortex, the course of development in the pith and cortex, and entitles the fifth "a comprehensive synopsis of the development and rhythm of the shoot." These chapters make almost no reference to the "mechanism" on which he lays so much stress in the introduction, and certainly do nothing toward revealing it. Profuse details encumber the pages; indeed, in places it almost seems as though the author had published his notebook. The "synopsis" covers 136 pages, a formidable number for a "glance" to take in. It is so beclouded with details and so unorganized that one cannot readily discover what the author is driving at. Great stress is laid throughout upon the cell-contents as determining factors in the final configuration of tissues, yet there is no indication of the nature of the relation, and such categories as "starch," "sugar," and "tannin" are treated as though they were definite substances. It is quite certain that the author has not yet succeeded in picturing clearly either the anatomical or physiological features of plant organization. Perhaps the next instalment will sum up his views in a definite and precise fashion.—C. R. B.

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[2] BOT. GAZ. **27**:146. 1899.

[3] BERTHOLD, G., Untersuchungen zur Physiologie der pflanzlichen Organisation. 8vo. pp. iv + 257. Leipzig; Wilhelm Engelmann. 1904.

MINOR NOTICES.

THE TENTH AND ELEVENTH parts of ROTH'S[4] *Die europäischen Laubmoose* complete the second volume and the work. Supplements to both volumes and indexes to accepted names and synonyms in the second volume make up the larger portion of the eleventh part. The four indexes (two in the first volume) should have been combined into one for convenience, though we are thankful for full indexing of any kind. The author and publisher deserve special commendation for the promptness with which the work has been issued. The book will be almost as useful to American as to European bryologists, and the total price, 44 marks, for a work with 62 plates and nearly 1400 pages is certainly very reasonable.—C. R. B.

MAJOR SQUIER,[5] of the Signal Corps, U. S. A., in experimenting with field wireless telegraphy, has incidentally paid some attention to the conductivity and electromotive force of live trees. Being, naturally enough, unfamiliar with the literature, he has rediscovered a number of well-known phenomena and raises some questions which have already been investigated. The discharge of a powerful induction coil and Leyden jars through live-plant electrodes, and the so-called "floral spectra" with lines of carbon, nitrogen, sodium, etc., are more novel than valuable.—C. R. B.

Die Pflanzenfamilien drags on, the sections on mosses and lichens not yet being complete. The former are being elaborated by BROTHERUS.[6] The last two parts to appear (219, 220) treat the remainder of the Bryaceae, the monotypic Leptostomaceae, Mniaceae (72 spp.) Rhizogoniaceae (35 spp.), Aulacomniaceae (11 spp.), Meesiaceae (11 spp.), Catoscopiaceae (monotypic), Bartramiaceae (400 spp.), Timmiaceae (10 spp.), Weberaceae (13 spp.), Buxbaumiaceae (2 spp.), Calomniaceae (3 spp.), and Georgiaceae (5 spp.). The Polytrichaceae are just begun.—C. R. B.

BEAL[7] has published what is really a third edition of the list of vascular plants that bears the title "Michigan Flora." The first edition (1880) was prepared by C. F. WHEELER and ERWIN F. SMITH; the second (1892) by C. F. WHEELER and W. J. BEAL; and this third edition bears only the name of Professor BEAL. Besides the incorporation of additional plants, the most notable

4 ROTH, G., Die europäischen Laubmoose. 2 Band, Lief. 10, 11. Imp. 8vo. pp. 573–734. *pls. 41–62.* Leipzig: Wilhelm Engelmann. 1904. Each *M* 4. Parts not sold singly.

5 SQUIER, GEORGE O., On the absorption of electromagnetic waves by living vegetable organisms. 8vo. pp. 32. Reprinted from Maj. Gen. Arthur MacArthur's Report to War Dept. on Military Maneuvers in the Pacific Division, 1904.

6 ENGLER and PRANTL, Die natürlichen Pflanzenfamilien. Lief. 219, 220. pp. 577–672. *figs. 264* in *37*. Leipzig: Wilhelm Engelmann. 1904. *M* 6 or 12.

7 BEAL, W. J., Michigan Flora. A list of the fern and seed plants growing without cultivation. Reprinted from 5th Report of the Mich. Acad. Sci. 1904.

change in the present edition is the use of the Engler and Prantl sequence as presented in Britton's *Manual*.—J. M. C.

THE SECOND FASCICLE of LÉVEILLÉ's[8] monograph of Oenothera has appeared, the first fascicle having been noticed in this journal for April 1903 (p. 296). Naturally it is of great interest to American taxonomists, and contains a profusion of illustrations. The genera Eulobus and Gayophytum have been merged under Oenothera, and *O. bistorta* Nutt. has been replaced in great part by *O. chieranthifolia* Hornem.—J. M. C.

THE FOREST WEALTH OF OREGON is the title of a small pamphlet prepared by E. P. SHELDON[9] setting forth the forest resources of the state, with a list of forest trees and larger shrubs. Of these thirty-eight are gymnosperms.—C. R. B.

IN CONTINUING his revision of Eucalyptus, MAIDEN[10] presents *E. stellulata*, *E. coriacea*, and *E. coccifera*, under each species giving the description, synonyms, range, and affinity.—J. M. C.

THE EIGHTH VOLUME of the fourth series of HOOKER's *Icones Plantarum* closes with the publication of the fourth part January 1905. The plates of this part are 2776–2800.—J. M. C.

NOTES FOR STUDENTS.

HESSELMAN[11] has published a paper on Swedish meadows, which should be carefully read by all who are engaged in ecological research, since no recent paper has gone more fundamentally or successfully into the real problems of ecology. The studies have been carried on for nearly a decade, and in a rather limited area in the neighborhood of Stockholm, and with especial detail on the little island of Skabbholmen. The "Laubwiesen" are meadows in which there are scattered deciduous trees, the general aspect being park-like. They might perhaps be regarded as edaphic savannas. These formations are rich in herbs and grasses, and are essentially without low shrubs. At an earlier time the "Laubwiesen" covered extensive areas, but they are now restricted to what may be called new terranes, especially near the coast and about inland lakes. They seem to be particularly favored by maritime climates and calcareous soils. Floristically the vegetation is closely related to that of oak or beech woods on calcareous soil rich in humus. The dominant trees are ash, oak, linden, elm, and beech,

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[8] LÉVEILLÉ, H., Monographie du genre Oenothera. Le Mans. 1905. 100 fr.

[9] SHELDON, E. P., The forest wealth of Oregon. 12mo. pp. 32. *pls. 4*. Portland, Ore. Printed by direction of the Lewis and Clark Exposition Commission. 1904.

[10] MAIDEN, J. H., A critical revision of the genus Eucalyptus. Part V. *pls. 4*. Published by the authority of the Government of the State of New South Wales. 1904. 2s. 6d.

[11] HESSELMAN, H., Zur Kenntnis des Pflanzenlebens schwedischer Laubwiesen. Eine physiologisch-biologische und pflanzengeographische Studie. Beih. Bot. Cent. **17**: 311–460. *pls. 4–8*. 1904.

while the hazel is the chief shrub. The herbage is so dense as to exclude most mosses. The formation is often developed from salt marshes and HESSELMAN gives an interesting account of the developmental stages. The alder is commonly the pioneer ligneous form, and is followed by the ash. The author's most important contribution is experimental, and in this field he has clearly pushed forward the frontiers of our knowledge. His results deal chiefly with the ecology of starch formation, respiration, and transpiration. An important feature of his results is that they are rigidly quantitative. In the study of starch formation, close correlation was made with the light intensity, in which WIESNER's methods were employed. The "Lichtgenuss" varied from about 1 in open meadows to $\frac{1}{65}$ in dense hazel thickets. Much formation of starch was observed under the trees in early spring, and all through the summer as well in open meadows. The very same species that were found rich in starch in the woods in spring were found nearly without it in the summer shade. In the ash woods, however, starch is formed in summer by all herbs, except a few which are always poor in starch. This is correlated with the greater light intensity of ash woods, as compared with other kinds. Anatomical studies are also correlated with the above, and it is found that those plants which develop their leaves late in the forest shade have a weak development of palisade cells, while the plants which develop their leaves in the intenser light of early spring have more palisades. Trees with high light requirement were found to have but one leaf type, namely a sun leaf; while shade-enduring trees have both sun or shade leaves, depending on their growth conditions. Trees of the first class, such as the ash or birch, show starch formation in all leaves, wherever placed. Plants of the second type, such as oak or hazel, do not form starch in the innermost leaves. In equal light shade leaves form more starch than do sun leaves of the same species. Starch formation decreases from spring to summer in the woods more in sun plants than in shade plants. Shade plants respire much less than do sun plants. Shade plants transpire much less in the shade than do sun plants in the sun, especially on hot or dry days. The leaf surface being equal, plants transpire more as they have a greater development of palisade cells, though many have thought that palisade cells in some way check transpiration, since they commonly occur where such protection seems necessary.

The great detail with which HESSELMAN's studies have been pursued, and the tedious quantitative experiments, may well furnish a model for many workers in all lands. The paper is illustrated by several reproductions of photographs, and a number of text figures showing anatomical details.—H. C. COWLES.

THE ACHROMATIC figure in *Pellia epiphylla* has been investigated again, this time by GREGOIRE and BERGHS,[12] who have devoted their attention to the intrasporal mitoses of the germinating spore, and in some degree to the first mitosis in the spore mother-cell. The figures show some improvement over those of their predecessors and indicate a technique of the highest order. The researches of

[12] GREGOIRE, V., and BERGHS, J., La figure achromatique dans le *Pellia epiphylla*. La Cellule **21**: 193–233. *pls. 1–2.* 1904.

DAVIS and of the reviewer are frequently discussed through the work. In the opinion of the reviewer, our technique was also good and enabled us to see the structures described in the present paper, so that differences in conclusions are due in large measure to differences in interpretation of structures which other investigators have seen. The present writers support the reviewer's conclusions that the two poles of the chromatic figure arise in succession and independently, and also that the nuclear membrane belongs to the category of the *Hautschicht*. Without details, some of the principal conclusions are the following: In the segmentation of the spore (beginning with the third mitosis) the asters are continuous from pole to pole and the achromatic figure surrounds both the nucleus and the "polar vesicles" ("caps"). The achromatic figure results simply from a rearrangement of the general cytoplasmic reticulum. Neither the nucleus nor the vesicles (caps) contribute to the formation of the spindle. The vesicles are nothing but nuclear sap diffused into the cytoplasm. After mitosis the achromatic structures are transformed into the general cytoplasm of the cell. At no stage is there a genuine centrosphere or centrosome. The first mitoses in the germinating spore and the mitoses in the spore mother-cell show neither asters nor polar vesicles (caps), but in other respects the evolution of the achromatic figure is the same as in other mitoses. The authors hold that there is no distinction between kinoplasm and trophoplasm. No importance is attached to the structure described by others as a centrosphere. These researches on Pellia contradict many theories in regard to the mechanism of mitosis.—C. J. CHAMBERLAIN.

PHILLIPS[13] has contributed some startling discoveries to an already confused subject. Particularly interesting are his conclusions as to the structure of the central body of the Cyanophyceae, which he regards as a nucleus, and the occurrence of sexual fusions in the formation of the spores. In unsectioned filaments, since "sections revealed very little that could not be seen equally as well in the uncut object," the author has discovered that the chromatin of the central body is aggregated in hollow vesicles in the resting cell. This vesicular appearance disappears in the dividing cell and the chromatin granules become arranged in a loose network. In this condition, he finds the minute granules themselves multiplying by transverse division. Nuclear division follows, which may be by one of two modes, both occurring even in the same species. One, according to the author, evidently corresponds to a direct division, while the other is a primitive mode of karyokinesis. The latter resembles closely the method of mitosis described by KOHL,[14] in which a double transverse division occurs in the spirem thread, never a longitudinal splitting. The author has also discovered thick-walled spores in Oscillatoria, which are produced after the fusion of several cells

[13] PHILLIPS, O. P., A comparative study of the cytology and movements of Cyanophyceae. Contrib. Bot. Lab. Univ. Pennsylvania **2**:237–335. *pls. 23–25*. 1904.

[14] KOHL, F. G., Ueber die Organisation und Physiologie der Cyanophyceenzelle und die mitotische Theilung ihres Kernes.

(one to four) into one, and after certain adjoining cells, called by him "nurse cells," have gradually disintegrated and given up their chromatin to the forming spore. The first fusion is regarded as probably a sexual act, but he does not appear to attach this importance to the giving up of the chromatin by the "nurse cell." His figures of the spores of Oscillatoria remind one of small hormogonia, while his "nurse cells" evidently correspond to the cells adjacent to the hormogonia which have been heretofore regarded as collapsed, dead cells.

The author makes a third distinct contribution, which is also far from convincing, in that he finds that the movements of the Cyanophyceae are caused by delicate cilia, distributed along the sides of the filament.—EDGAR W. OLIVE.

THE OVULE of seven genera of cycads, Zamia, Macrozamia, Ceratozamia, Encephalartos, Bowenia, and Dioon, have been investigated by Miss STOPES.[15] The work was done in GOEBEL'S laboratory and the standpoint is that of phylogenetic anatomy.

The integument in all the forms studied is differentiated into three layers, the outer and inner being fleshy, while the middle is the well-known stony layer. The inner system of bundles does not lie in the nucellus (which in all living cycads and their fossil relatives is absolutely without vascular bundles), or between the nucellus and integument, as is commonly supposed, but belongs to the inner fleshy layer of the integument. These bundles, which in all the seeds examined are similar and simple, sometimes extend beyond the nucellus, reaching almost to the micropyle. The larger ones are collateral and the phloem is not strongly developed. It is often hard to determine where the protoxylem lies, but, in general, the bundles are endarch. In the simplest case, these bundles come from the branching of a single concentric or nearly concentric bundle.

The bundles in the outer flesh, with few exceptions, are collateral, with outer phloem and inner mesarch xylem. The central strand, from which these bundles come, is usually concentric.

It is certain that the fossil seed, Lagenostoma, is related to living cycads. Evidence indicating this relationship is presented in detail and is illustrated by diagrams. Miss STOPES believes that Lagenostoma lies near the common origin of the two groups. The single integument of the cycads is thought to correspond to the two separate integuments of Lagenostoma.

It is particularly interesting to note that Cycas itself, generally thought to be the most primitive of the cycads, has the most highly developed seed to be found in the group.—C. J. CHAMBERLAIN.

ZACHARIAS[16] adds another article to his long series of writings on the structure of the cyanophyceous cell, which leaves the subject in deeper uncertainty than ever. This latest addition is in the main a sharp criticism of the methods and

[15] STOPES, MARIE C., Beiträge zur Kenntniss der Fortpflanzungsorgane der Cycadeen. Flora **93**:435–482. *figs.* 37. 1904.

[16] ZACHARIAS, E., Ueber die Cyanophyceen. Jahrb. Hamburg Wiss. Anat. **21**:49–89. *pl.* 1. 1903.

conclusions of KOHL and a reiteration of the principal results of his paper of 1890. He thinks that KOHL's "chromatin granules" were probably his small "Zentralkörner," or slime globules. While ZACHARIAS denies that it has been proved that the central body contains any granules other than the "Zentralkörner," yet he leaves the question still open as to the possibility of the existence of chromatin in this enigmatical body. He asserts strongly his belief, however, after an examination of the preparations of both KOHL and HEGLER, that there are no structures present which can be called chromosomes, as maintained by KOHL and BÜTSCHLI.

ZACHARIAS adds in the present paper some new observations on the nature of the cyanophycin granules. After repeating his earlier experiments on the effects of dilute HCl, he comes to a conclusion somewhat at variance with his earlier results, namely, that the granules in certain cases are not actually dissolved by the acid, but that nevertheless they undergo some change. He concludes, further, that there is no difference in the behavior of the cyanophycin toward dilute HCl and toward pepsin, thus disputing the results of HEGLER and KOHL. The author as well cannot agree with these investigators in their conclusions as to the albuminous and crystalloidal nature of the cyanophycin granules, although he adds nothing in support of his earlier supposition of their carbohydrate nature.

In regard to the duration of cyanophycin in filaments grown for a long time in the dark, ZACHARIAS differs from HEGLER and KOHL in asserting that there is no complete disappearance of cyanophycin and slime.—EDGAR W. OLIVE.

KOERNICKE reviews critically the present condition of researches upon the plant cell,[17] confining his attention to the morphological aspect now commonly spoken of as cytology. A little more than one half the work is devoted to the cytoplasm, the rest dealing with the nucleus.

That modern preparations do not show a series of artifacts but give a reliable view of structures, is proved by observations upon living material. The cytoplasm is regarded as consisting of two distinct substances, the kinoplasm and the trophoplasm. Spindle formation is described in all groups and the various views are clearly presented. The centrosome problem is discussed at some length. An impartial summary of the literature dealing with the blepharoplast is given, but the author expresses no opinion as to its homology. The nuclear membrane, cell plate, and *Hautschicht* are regarded as kinoplasmic structures. The paragraphs on protoplasmic continuity are especially valuable because the important investigations are so recent. Less attention is paid to the cell wall.

In treating the nucleus, the author deals principally with the works which have appeared since 1896, the date of Zimmerman's book on the nucleus, since when many investigators have studied the nuclei of the lower plants, especially the schizophytes and yeasts. Of course, the discussion of the chromatin occupies most of the space devoted to the nucleus. It is rather surprising that the Chara-

[17] KOERNICKE, M., Der heutige Stand der pflanzlichen Zellforschung. Ber. Deutsch. Bot. Gesells. **21**: Generalsammlungs-Heft 66–134. 1904.

ceae, Liliaceae, and Amaryllidaceae should be credited with the largest nuclei, for their nuclei are small when compared with those of the eggs of some gymnosperms.

No figures are given, but the references are very numerous and authority is cited for every statement.—C. J. CHAMBERLAIN.

AFTER REVIEWING several of the more important publications regarding the statolith theory, TISCHLER[18] states that adequate evidence to establish a correlation between movable starch grains and the perception of the gravitation stimulus is not available; and it is his opinion that such evidence cannot, with present methods, become available, for the simple reason that while the reaction may be optically observed the perception is hidden and a constancy of quantitative relation between the two cannot be depended upon. For similar reasons, the author believes a demonstration of the statolith theory cannot come from the study of organs which are little or not at all reactive; hence we must regard his contribution as consisting of merely circumstantial evidence. The general trend of the paper is that in the various types of roots slightly or not at all geotropic, geotropism and starch migration are coincident and associated phenomena. He finds that in adventitious roots which are constantly ageotropic these starch grains are either not present in the cap or if present are irregularly distributed. In temporarily ageotropic roots the starch grains are either absent or if present are irregularly distributed during the ageotropic period. With incipient geotropism, however, the starch grains appear if previously absent, and commence to collect and function as statoliths. When geotropic response is prevented by the application of stronger stimuli, the starch grains which would otherwise change position to function as statoliths do not do so. Some of the orchids having aerial roots slightly geotropic do not have starch grains, and the author calls in chloroplasts of the root-cap to act as statoliths.—RAYMOND H. POND.

PALEOBOTANICAL NOTES.—STENZEL[19] has just published a very elaborate and valuable monograph describing all the known forms of fossil palm-wood.—NATHORST[20] briefly summarizes our knowledge of Antarctic fossil floras. A rather rich deposit of Jurassic age on Louis-Philippe Land yields numerous remains of Cladophlebis, besides representatives of Brachyphyllum, Elatides, Palissya, Taxites, Araucarites, Otozamites, Pterophyllum, Equisetum, Sagenopteris, Thinnfeldia, Scleropteris, and Stachypteris; all characteristic Jurassic forms, emphasizing the uniform cosmopolitan character of the Jurassic flora even in lat. 63° 30′ S. Seymour Island in lat. 64° S. yields fragments of a dicotyledon, of Araucarites, and of a conifer resembling Sequoia. The Malouine Islands furnish

[18] TISCHLER, G., Ueber das Vorkommen von statolithen bei wenig oder gar nicht geotropischen Wurzeln. Flora **94**: 1–68. *figs. 31.* 1905.

[19] STENZEL, K. G., Fossile Palmenhölzer. Beitr. Palaeont. u. Geol. Oesterr. Ungarn. fol. pp. 182. *pls. 22.* 1904.

[20] NATHORST, A. G., Compt. Rend. **138**: 1447–1450. 1904.

fragments of an Asterocalamites indicative of Upper Devonian or Lower Carboniferous age.—MAURY[21] reports *Hicoria minor*, *Castanea vulgaris*, *Fagus pliocenica*, *Ilex aquifolium*, and *Bambusa lugdunensis* from a new Pliocene locality at Capelle in the Department of Cantal, south central France.—HARTZ[22] records characteristic spikes of the common *Dulichium arundinaceum* (L.) Britt. of eastern North America, along with the remains of Picea, Brasenia, Hydrocharis, Carpinus, and Betula, from the interglacial of Brörup in southern Jutland, Denmark.—EDWARD W. BERRY.

HUME[23] calls attention to the anthracnose of the pomelo in Florida caused by *Colletotrichum gloeosporoides*. He reported in 1900 an injury to pomelo leaves caused by this fungus, a disease that was then referred to as leaf spot. HUME first noticed the same fungus on pomelo fruits in 1901 and now reports it upon twigs of the same plant. It is also known to cause a disease of lemon and lime fruits and is frequently seen on the leaves and twigs of the sweet orange and rarely on its fruit. Trees whose vitality has been reduced by improper soil conditions or by mechanical injury or through injuries inflicted by winds, frost, insects, or other diseases are more subject to this anthracnose than trees in perfect condition. It is recommended that all diseased fruits and branches be removed and burned and the trees sprayed with the usual Bordeaux mixture early in the season from May to July. Spray treatment should particularly be applied to trees whose branches show any evidence of the anthracnose. It is also recommended that the fruit be washed, before packing, with water to which has been added some ammoniacal copper carbonate solution or potassium sulfid. The later treatment will prevent the serious injury to the fruit that frequently occurs on the way to market.—E. MEAD WILCOX.

BY MEASURING the distance between oppositely located branches of small trees and shrubs, GANONG[24] has established that with autumnal defoliation the branches commence an inward movement toward the main axis. This inward movement continues after defoliation, reaching a limit with the full winter condition in January. With the swelling of the buds in April a reverse movement commences which continues through vernal foliation to the full summer condition in June. The movement accompanying defoliation and foliation is attributed merely to decreasing and increasing weight of branches, by loss and gain of leaves, but the intervening movement is regarded as indirectly thermometric because from experimental data (quite limited and so regarded by the author) it seems that the movement is correlated with variations in the amount of water in the stem and

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[21] MAURY, P., Le Monde des Plantes, Nov. 1903, pp. 54–55.

[22] HARTZ, N., Meddel. Dansk. Geol. Foren. **10**:13–22. *figs. 5.* 1904.

[23] HUME, H. HAROLD, Anthracnose of the pomelo. Bull. Florida Exp. Stat. 74:157–172. *pl. 1–4.* 1904.

[24] GANONG, W. F., An undescribed thermometric movement of the branches in shrubs and trees. Ann. Botany **18**:631–644. *figs. 6.* 1904.

that fluctuations in temperature induce such variations in water content. The author regards the movement as without ecological significance. The practical absence of other literature on this subject gives the paper a quality of uniqueness, and although negative results appear to equal the positive in number, the high ideals of the accurate and unprejudiced worker are everywhere suggested.—RAYMOND H. POND.

GANONG has published in an earlier paper his[25] views concerning some of the underlying principles of ecology, and to these he has added others[26] dealing especially with adaptation. After criticising the idea that ecology is synonymous with ecological geography, and deploring the lack of any significant advance in ecological methods in recent years, he plunges into a discussion of the philosophy of adaptation. Five principles are laid down; the first, as to the reality of adaptation, and the last, as to the inevitable imperfection of all adaptation, must meet with general acceptance. The second principle, dealing with the evolutionary phylogeny of adaptation, is taken up from a Lamarckian standpoint. GANONG thinks that the concomitance of diverse adaptations in a single species is to be accounted for best along Lamarckian lines. While this is doubtless true, there are as many objections to the Lamarckian as to other theories; indeed, some authors (DETTO[27] for example) regard the Lamarckian theory as the most untenable of all. The third and fourth principles are concerned with adaptation as a race process rather than an individual process, and with the metamorphic nature of its origin.—H. C. COWLES.

TANSLEY'S[28] address before the British Association on *The problems of ecology* is very suggestive, and indicates the rapid progress which is being made along ecological lines in the British Isles. TANSLEY proposes to narrow the definition of ecology to include only its geographic aspects. For instance, he would include the geographic distribution of pollination mechanisms, but would exclude the study of pollination mechanisms themselves. The reviewer can well imagine what a shock this will give to those who imagine that ecology includes nothing but the study of seed dispersal and pollination! TANSLEY uses as a synonym of ecology topographical physiology, which is practically identical with what the reviewer has termed physiographic ecology. It does not seem likely that TANSLEY'S view as to the limits of ecology will meet general approval, since the broader term has been so universally regarded as highly desirable and much needed. The distinctions between descriptive and experimental ecology are well brought out, and proper emphasis is laid upon the ultimate aim of ecology, the discovery of causes.—H. C. COWLES.

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[25] See BOT. GAZ. **36**: 447–453. 1903.

[26] GANONG, W. F., The cardinal principles of ecology. Science **19**: 493–498. 1904.

[27] See BOT. GAZ. **38**: 385–386. 1904.

[28] TANSLEY, A. G., The problems of ecology. New Phytologist **3**: 191–200. 1904.

PARTHENOGENESIS in Taraxacum and Hieracium is being investigated by MURBECK.[29] Two species of Taraxacum were studied, *T. vulgare* (Lam.) Raunk., which produces abundant, but imperfect pollen, and *T. speciosum* Raunk., which produces no pollen at all. The embryo-sacs present nothing unusual in their appearance. The egg cell increases in size, its nucleus divides, and the embryo is formed just as if normal fertilization had occurred. The polar nuclei fuse and then divide, giving rise to the endosperm.

Three species of Hieracium were examined, *H. grandidens* Dahlst., *H. serratifrons* Almqu., and *H. colophyllum leiopogon* Gren. In general, the embryo-sac resembles that of Taraxacum. The embryo is developed from the egg, and embryos are formed in eighty per cent. or ninety per cent. of the flowers, so that it is probable that these species are always parthenogenetic. A full account with illustrations is to follow.—C. J. CHAMBERLAIN.

MISS COOLEY[30] has given an account of the ecology of the tamarack, which has been based upon a considerable amount of field study in various states. Attention is called to the unusally wide range of the tree, which occurs in five of MERRIAM'S zones. The tree displays great vigor even at the extreme northern and southern limits. The range of topographic habitat is also wide; although commonly thought of as a swamp tree, it occurs in almost every habitat, even to the most xerophytic. Among the characteristics which may serve to give this tree its great success, Miss COOLEY mentions the abundance of seeds, the frequency with which the tree produces seeds, the power of the seedlings to endure light, indifference to soil, and rapid growth. A great disadvantage is the inability of the tree to endure shade, or to compete with other forest trees. In a Maine area a tamarack swamp has succeeded a hardwood forest.—H. C. COWLES.

APOGAMY in Hieracium is described by OSTENFELD,[31] who in 1903 in a paper written conjointly with RAUNKIAER reported that twenty-two species of the genus had been found to produce seeds even after pollination had been prevented. OSTENFELD now finds that many of the seeds thus produced germinate normally. In the botanical garden at Copenhagen two species of Hieracium were found which produce only female flowers, a careful examination showing not a single pollen grain. These plants were isolated under control in the greenhouse and produced abundant seeds. Whether the embryos arise from unfertilized eggs was not determined. Attempts to germinate the pollen of pollen-bearing species failed. This would indicate that the great number of forms in the genus, usually attributed to hybridization, are due rather to mutation. All attempts to produce hybrids were unsuccessful.—C. J. CHAMBERLAIN.

[29] MURBECK, SV., Parthenogenese bei den Gattungen Taraxacum und Hieracium. Bot. Notiser **1904**: 285–296.

[30] COOLEY, GRACE E., Silvicultural features of *Larix americana*. Forestry Quarterly **2**: 148–160. 1904.

[31] OSTENFELD, C. H., Zur Kenntniss der Apogamie in der Gattung Hieracium. Ber. Deutsch. Bot. Gesells. **22**: 376–381. 1904.

THE NUTRITION of the chromatin thread and the chromosomes by nucleolar material is well shown, according to VON DERSHAU,[32] in the active nuclei of the parietal endosperm of *Fritillaria imperialis*. The increasing staining capacity of the chromatin thread is correlated with the dissolution of the nucleoli; besides, slender connections unite the nucleoli and the thread and indicate a streaming of material. Resting nucleoli are spherical or ellipsoidal, while those in the active condition are more or less irregular or star-shaped. A study of karyokinesis showed a direct relation between the nucleoli and spindle formation. An investigation of the development of the peristome of *Funaria hygrometrica* and *Bryum argenteum* showed that the nucleoli play an active part in the local thickenings of the cell wall. VON DERSHAU draws the conclusion that the nucleoli consist of reserve substance.—C. J. CHAMBERLAIN.

BISPORANGIATE STROBILI have not hitherto been observed in Juniperus, and only a single case has been reported for the Cupressineae. An interesting case is described by RENNER[33], who discovered a plant which bears such strobili almost exclusively. Only on a few twigs, and here only toward the tips, was there a transition to purely ovulate strobili. In the base of the bisporangiate strobilus there are a few sterile leaves, above these are two or three whorls of staminate sporophylls, and at the tip are the ovules. There may be a whorl of sterile leaves between the staminate sporophylls and the ovules. The pollen develops normally, but so much later than the ovules that there is no possibility of self-pollination. RENNER sees in these bisporangiate strobili a suggestion of the method by which the bisporangiate flowers of angiosperms may have arisen.—C. J. CHAMBERLAIN.

WHITE[34] has published the first American contribution to our knowledge of those paleozoic fern-like plants which had acquired the seed-habit, a subject under active investigation abroad of late. He records abundant gymnospermous fruits in the fern-genus Aneimites from the lower Pottsville of West Virginia. They are usually borne singly at the apices of the slightly dilated terminal extensions of the outer pinnae, and show some slight indications of a pollen-chamber. They have been found only as impressions and therefore cannot be compared properly with the beautifully preserved foreign specimens showing internal structure. The author is of the opinion that the American form is more closely related to Lagenostoma than to any other cycadofilicinean type at present recognized as seed-bearing.—EDWARD W. BERRY.

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[32] DERSHAU, MAX VON, Wanderung nukleolarer Substanz während der Karyokinese und in lokal sich verdickenden Zellen. Ber. Deutsch. Bot. Gesells. **22**: 400–411. *pl. 21.* 1904.

[33] RENNER., OTTO, Ueber Zwitterblüthen bei Juniperus communis. Flora **93**: 297–300. *fig. 3.* 1904.

[34] WHITE, D., Smithsonian Miscellaneous Collections **47**: 322–331. *pls. 47–48.* 1904.

PARTHENOGENESIS in *Wikstroemia indica*, one of the Thymelaeaceae, is announced in a preliminary paper by WINKLER.[35] The pollen develops imperfectly or not at all, and attempts to germinate the pollen by the usual methods were unsuccessful. Although pollination was prevented, embryos developed, and sections showed that the embryos arise from unfertilized eggs. The behavior of the chromatin will be studied later. Up to date the angiosperms in which parthenogenesis has been shown to exist are *Antennaria alpina*, *Alchemilla* (several species), *Thalictrum purpurascens*, *Taraxacum officinale*, *Hieracium*, and *Wikstroemia indica*. *Gnetum Ula* is the only gymnosperm in which parthenogenesis has yet been reported.—CHARLES J. CHAMBERLAIN.

OLSSON-SEFFER[36] has written a short defense of LINNAEUS, à propos of the recent Swedish biography by T. M. FRIES. The particular occasion for OLSSON-SEFFER'S paper is a choleric and most unjust attack upon LINNAEUS by KALISCHER and HANSEN. Considerable attention is also paid to the unfair treatment which is accorded to LINNAEUS in SACHS'S *History of Botany*. There can be no doubt that LINNAEUS has a secure place among the greatest botanists of all time, and the imputations that have been cast upon him are certain to be less harmful to the renown of LINNAEUS than to the reputation of his accusers.—H. C. COWLES.

INTERCELLULAR PROTOPLASM has been further investigated by KNY.[37] The principal material was cotyledons of *Lupinus albus* and *L. angustifolius*. That the protoplasm in the intercellular spaces is in direct communication with that of the neighboring cells is probable from the fact that the spaces contain starch grains. If there is protoplasmic continuity between the intercellular spaces and the neighboring cells the absence of nuclei in the spaces would not be strange. Perforations and connecting threads could not be identified positively. How the protoplasm gets into the spaces the author is not yet ready to explain.—C. J. CHAMBERLAIN.

THE PHYTON THEORY is supported by COL in a lengthy paper[38] which deals mainly with abnormally placed vascular bundles in dicotyledons. Starting with the Campanulaceae the author has extended his observations to a large number of families, and reaches the conclusion that the bundles in question are normal in part of their course, though frequently for only a short distance. The chief arguments advanced in favor of the phyton theory are (1) the bundles coming from the leaves diminish in volume as they descend through the stem; (2) practically

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[35] WINKLER, HANS, Ueber Parthenogenesis bei *Wikstroemia indica* (L.) C. A. Mey. Ber. Deutsch, Bot. Gesells. **22**:573–580. 1905.

[36] OLSSON-SEFFER, P., The place of Linnaeus in the history of botany. Jour. of Bot. **42**:262–269. 1904.

[37] KNY, L., Studien über intercellulares protoplasma II. Ber. Deutsch. Bot. Gesells. **22**:347–355. 1904.

[38] COL, A., Recherches sur la disposition des faisceaux dans la tige et les feuilles de quelques dicotylédones. Ann. Sci. Nat. Bot. **8**: 20: 1–288. 1904.

all of the vascular formations of the stem supply appendicular organs.—M. A. CHRYSLER.

HOLLICK[39] has published further additions to the Cretaceous flora of Long Island, treating of plants from the Northport Clays and from the vicinity of Hempstead Harbor, Oyster Bay, and Montauk Point. Nine new species, including an interesting form of Marsilia, are described. The supposed palm Serenopsis is reconsidered in the light of better material and is definitely referred to Nelumbo. This leaves a species of palm (about to be published by the undersigned in *Torreya*) coming from the mid-Cretaceous of Delaware and Maryland, as the earliest known plant of this type from American strata.—EDWARD W. BERRY.

NEWCOMBE,[40] in his presidential address before the Michigan Academy of Science, contrasts the old and new types of biological surveys, and makes a strong appeal for the new progressive and definite survey of the ecological type, accompanied by detailed maps, such as has been carried on by FLAHAULT in France, by the SMITHS in Britain, and begun in Michigan by LIVINGSTON. Concise statements are made concerning the uses of such a survey, both scientific and practical. It is much to be hoped that the plan here advocated will be carried out, not only in Michigan but in many other states as well.—H. C. COWLES.

LAWRENCE gives the results of his investigation of the apple scab in Washington.[41] He was able, as were CLINTON and others, to confirm the discovery made by ADERHOLD, that *Fusicladium dendriticum*, found as a parasite on the fruit and leaves of the apple during the summer, is but a stage in the development of *Venturia inaequalis*, the perfect form being found on the dead leaves as a saprophyte during the winter. He recommends that the fallen leaves should be gathered and destroyed and that the usual spraying with Bordeaux mixture be conducted in the spring.—E. MEAD WILCOX.

CHEMOTAXIS of the sperms of Marchantia toward a number of albumins, globulins, nucleo-albumins, proteids, and enzymes, is the subject of a paper by by LIDFORSS.[42] Out of nineteen substances tested only two gave a negative result; all the others attract the sperms when in the right concentration. The author suggests that proteid substances are probably the main factor in the attraction of such sperms to the archegonia in nature, as well as in the tropism of pollen tubes. There is some evidence that Marchantia sperms are positively aerotropic. —B. E. LIVINGSTON.

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[39] HOLLICK, A., Additions to the paleobotany of the cretaceous formation on Long Island. II. Bull. N. Y. Bot. Gard. **3**:403–418. *pls. 70–79.* 1904.

[40] NEWCOMBE, F. C., A natural history survey for Michigan. Annual Report Mich. Acad. Sci. **6**:28–36. 1904.

[41] LAWRENCE, W. H., The apple scab in western Washington. Bull. Wash. Exp. Stat. **64**:1–24. *figs. 1–5. pl. 1–2.* 1904.

[42] LIDFORSS, B., Ueber die Reizbewegungen der Marchantia-Spermatozoiden. Jahr. Wiss. Bot. **41**:65–87. 1904.

HUME[43] has published an account of observations and experiments regarding five serious diseases of the Irish potato that are known to occur in Florida: late blight, caused by *Phytophthora infestans;* early blight, caused by *Alternaria solani;* scab, caused by *Oospora scabies;* rhizoctonia blight, caused by a species of *Rhizoctonia;* and bacterial blight, caused by *Bacillus solanacearum.* A brief discussion of the nature and effects of each disease is accompanied by statements as to the proper methods of control to be employed in each case.—E. MEAD WILCOX.

FROM A consideration of the various causes assigned by different authors as inducing flower-formation, LOEW[44] believes that such causes have one common physiological factor, namely, an increased concentration of sugar. He advances the theory that flower-formation is a phenomenon of irritability; that a certain concentration of sugar in the plant stimulates the embryonic substance to differentiate male and female nuclei. Unfortunately, the evidence offered is very limited and not at all conclusive.—RAYMOND H. POND.

NATHANSOHN'S last work on permeability of the plasmatic membranes of plants,[45] which was reviewed in these pages some time since,[46] includes in its discussion the results of a large series of experiments with the tissue of Dahlia tubers. The paper which embodied the details of this work, though actually published before the one already reviewed, has but recently come to hand.[47] Those interested in this subject will need to read the two papers together.—B. E. LIVINGSTON.

THE FIRST NUMBER of the second series of KARSTEN and SCHENCK'S[48] *Vegetationsbilder* comes from the hand of ULE, the well-known student of the South American tropics. The number is devoted to the illustration of some characteristic epiphytes of the Amazon district, and the standard of the preceding numbers is fully maintained. Among the epiphytes figured are Nidularium, Platycerium, Polypodium, Cereus, and Anthurium.—H. C. COWLES.

THE INFLUENCE of weak aqueous solutions of ether upon the growth of Spirogyra has been studied by GERASSIMOW.[49] In these cultures many of the

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[43] HUME, H. HAROLD, Potato Diseases. Bull. Florida Exp. Stat. **75**: 177–196. *pl. 1–4* and frontispiece. 1904.

[44] LOEW, OSKAR, Zur Theorie der blütenbildenden Stoffe. Flora **94**: 124–128. 1905.

[45] NATHANSOHN, A., Weitere Mitteilungen über die Regulation der Stoffaufnahme. Jahrb. Wiss. Bot. **40**: 403–442. 1902.

[46] BOT. GAZETTE **38**: 477. 1904.

[47] NATHANSOHN, A., Ueber die Regulation der Aufnahme anorganischer Salze durch die Knollen von Dahlia. Jahrb. Wiss. Bot. **39**: 607–644. 1904.

[48] KARSTEN, G., und SCHENCK, H., Vegetationsbilder. Zweite Reihe, Heft 1. E. ULE, Die Epiphyten des Amazonasgebietes. *Tafel 1–6.* Jena: Gustav Fischer. 1904. Single parts *M* 4; to subscribers *M* 2.50.

[49] GERASSIMOW, J. J., Aetherkulturen von Spirogyra. Flora **94**: 79–88. 1905.

cells swell laterally and thus become barrel-shaped. Certain cells without nuclei increase in length but never swell in this way. Thus the author concludes that the swelling is brought about in some manner through the action of the ether upon the nuclear mechanism.—B. E. LIVINGSTON.

TSCHIRCH[50] finds that many dicotyledonous plants possess two types of root in the same individual, one sort having a nutritive function and the other serving to fasten the plant to the substratum. The so-called "fastening roots" are distinguished by the presence of mechanical fibers and generally by the absence of pith and by the larger size of the central cylinder.—M. A. CHRYSLER.

R. M. HARPER[51] has continued his valuable ecological and taxonomic observations on the flora of Georgia, a state whose botany has been peculiarly unknown until these and previously noted[52] studies were made. In addition to critical taxonomic notes, these papers contain accounts of the author's itinerary, together with landscape figures and ecological remarks.—H. C. COWLES.

EPIPHEGUS VIRGINIANA has been studied by COOKE and SCHIVELY,[53] who find that the parasitic haustoria arise from the roots of the host, the beech, and not from the parasite. As is usual in such plants, there is a precocious endosperm, and the embryo is rudimentary. Bicollateral bundles are found both in the tuber and in the aerial shoot.—M. A. CHRYSLER.

WOODRUFFE-PEACOCK[54] has published some rather peculiar suggestions on the study of rock-soil floras. An immense number of habitat types are proposed, but no attempt is made at analysis. It is obvious that the author is not conversant with modern ecological literature.—H. C. COWLES.

THE STRUCTURE and sprouting of the seed, and the structure of the mature plant of *Cassytha filiformis* are described by Miss BOEWIG.[55] This plant, though a parasite resembling Cuscuta, has functional chlorophyll tissue, especially when growing in the shade.—M. A. CHRYSLER.

TANSLEY[56] gives an account of the methods which he has employed in ecological surveying with his classes on the coast of Brittany. The scheme makes possible accurate and detailed mapping.—H. C. COWLES.

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[50] TSCHIRCH, A., Ueber die Heterorhizie bei Dikotylen. Flora **94**: 68–78. 1905.

[51] HARPER, R. M., Botanical explorations in Georgia during the summer of 1901. Bull. Torr. Bot. Club **30**: 282–295, 319–342. 1903. Explorations in the coastal plain of Georgia during the season of 1902. Bull. Torr. Bot. Club **31**: 9–27. 1904.

[52] See BOT. GAZ. **34**: 386. 1902.

[53] COOKE, E., and SCHIVELY, A. F., Observations on the structure and development of *Epiphegus virginiana*. Contrib. Bot. Lab. Univ. Penn. **2**: 352–398. 1904.

[54] WOODRUFFE-PEACOCK, E. A., How to make notes for a rock-soil flora. Rural Studies Series, No. 5. Louth, 1904.

[55] BOEWIG, HARRIET, The histology and development of *Cassytha filiformis*. Contrib. Bot. Lab. Univ. Penn. **2**: 399–416. 1904.

[56] TANSLEY, A. G., A second experiment in ecological surveying. New Phytologist **3**: 200–204. 1904.

NEWS.

DR. ERNST HALLIER, the mycologist, died at Dachau, near Munich, December 20, 1904, at the age of seventy-three.

DR. A. ERNST, formerly privatdocent at the University of Zürich, has been appointed professor and director of the botanical laboratories.

MISS CLARA E. CUMMINGS, of Wellesley College, went to Jamaica in February, to spend several months in a study of the flora, especially the lichens.

A. S. HITCHCOCK, of the Division of Agrostology, Department of Agriculture, has purchased the grass herbarium of F. LAMSON-SCRIBNER, containing many of his types.

DR. ERNST ABBE, of Jena, whose name is so well known in connection with the optical apparatus of the Karl Zeiss establishment, died January 16 at the age of sixty-four years.

SIR JOSEPH HOOKER retired from the editorship of the *Botanical Magazine* at the close of 1904, after forty years of service. He is succeeded by SIR W. THISELTON-DYER.

AT THE MEETING of the Linnean Society on December 15, 1904, fifteen ladies were elected Fellows. Among those thus honored were Miss MARGARET BENSON and Miss ETHEL SARGANT.

AT THE ANNUAL MEETING of the Torrey Botanical Club, held on January 10, H. H. RUSBY was elected president in the place of ADDISON BROWN, who resigned after fifteen years of service in that office.

JOHN F. CROWELL, director of the Buffalo Botanical Garden, will visit Panama during February and March as an agent of the New York Botanical Garden, which will undertake botanical explorations in co-operation with the engineers of the Panama Canal Commission.—*Science.*

PROFESSOR N. L. BRITTON, Mrs. E. G. BRITTON, Dr. C. F. MILLSPAUGH, and Mr. M. A. HOWE sailed in January to New Providence for a further botanical exploration of the Bahaman archipelago. MRS. BRITTON will collect on New Providence, while the rest of the party will explore the Berry and Great Bahama groups.

THE MACMILLAN CO. announces for the spring a revised and enlarged edition with many new illustrations of CAMPBELL'S *Mosses and ferns*. They will also publish a book by MAUD G. PETERSON entitled *How to know wild fruits*, which classifies wild plants by their fruits. They are also to publish a translation of COHNHEIM'S *Chemistry of the proteids*, by Dr. GUSTAV MANN. The book will be of interest not only to chemists, but especially to biologists. The advance in the knowledge of proteids will be fully set forth.